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THE DUCK HAWK OF THE HUDSON RIVER PALISADES.

THE WHITE EGRET IN A FLOODED CYPRESS FOREST OF SOUTH CAROLINA.

SOME NOTABLE BIRD GROUPS AT THE AMERICAN MUSEUM OF NATURAL HISTORY.

AMERICAN BIRDS REALISTICALLY MOUNTED.

THE DUCK HAWK, HACKENSACK MEADOW, AND EGRET GROUPS.

THROUGH the courtesy of the American Museum of Natural History, the SCIENTIFIC AMERICAN SUPPLEMENT presents three bird habitat groups. Two of these, recently completed, are of special interest to residents of the vicinity of New York city. The first shows the duck hawk or peregrine falcon as it nests on the Palisades. This falcon is famed for its fearlessness and strength of wing and talon. Among falconers the peregrine was rated second only to the gyrfalcon and no person of lower rank than an earl was permitted to own and fly one of these noble hawks. The peregrine is found throughout the greater part of the world, but is nowhere common. Near New York city it is known to nest only on the less accessible ledges and cliffs of the Palisades and Hudson Highlands.

The third local group illustrates the bird-life of the New Jersey Hackensack meadows in August. During this month, and in September, these marshes are the home of myriads of birds which come to them to roost and to feed. Swallows of several species are comparatively rare in the marshes during the day, but late in the afternoon they stream in by the thousand, coming from every direction and steering their flight

BIRD LIFE OF THE HACKENSACK MEADOWS, NEW JERSEY.

AMERICAN BIRDS REALISTICALLY MOUNTED.

toward some regularly frequented roost in the reeds. They leave early in the morning, radiating to all points of the compass to scour the country for food. Red-winged blackbirds, bobolinks, now called reedbirds, and Carolina or sora rail are attracted to the marshes by the wild rice which ripens about this time; and the last two are now killed in large numbers. In August the marshes are remarkable not only for their birds but also for their flowers. Marsh mallows, cardinal flowers, jewel-weed, sagittaria, pickerel weed, loose-strife, wild sunflower, hempweed, vervain, gerardia and many other species bloom so luxuriantly that one might imagine that nature was holding a flower show.

The second group shows a part of a colony of the white egret in a flooded cypress forest of South Carolina. This habitat group was added to the series early in the year. Both the birds and their haunt are singularly picturesque. The nests are high in the trees and look out over the waters of a swamp through ragged cypress sprays and festoons of "Spanish moss." This is the egret that has been brought so near extermination by the plume-hunters. It is a matter for rejoicing that there still exists this large South Carolina rookery and, moreover, that it is within the precincts of a game preserve where continued protection is assured.

Certain cloud formations have the effect of increasing the intensity of illumination by diffusion. Other clouds act as absorbing media, and decrease the illumination intensity. Variations in intensity due to clouds are often of a large order, and sometimes occur suddenly. The skylight value at night, when there is no moon, is approximately 0.001 candle-foot. The intensity of moonlight is about 0.014 candle-foot. Daylight illumination varies in intensity from 2,000 to 8,000 candle-feet between the hours of 8 A. M. and 4 P. M.

THE IMPREGNATION OF TIMBER.

SEVERAL different means have been used, with more or less success, for impregnating wood; but the best effects have been obtained with oil or tar, owing to its extraordinary antiseptic qualities. Enormous quantities are employed for treating railway sleepers, telegraph poles, pit wood, and various classes of squared and dimensioned timber used for structural work of all kinds; and it will therefore soon become necessary to economize in the use of this valuable medium. Due to the relatively speaking high price of tar oil, its use has, however, not been so general as might be expected, in fact in many countries it has not been practicable to use it on a large scale at all, especially as the cells of the wood to be treated absorb this oil very greedily.

A change has now come over "the spirit of the dream," due, as might be expected nowadays to Teutonic influence, a German engineer having now succeeded in discovering a new process, which has been patented, whereby the tar oil is used in much smaller quantities, although the same effect is obtained. According to this process, the wood is not treated with the liquid tar oil, but with gases containing it; these gases being those obtained in such industries as wood and peat distillation, gas works, coke furnaces, *et hoc genus omne*. The company which has taken up the patent intends to place such plants for the impregnation of timber in communication with factories where gases of this kind are generated; and if the process should prove a success (of which there is not the slightest doubt), then plants of this kind would become of considerable value and importance, and municipal gas works could even be turned to account for impregnating large quantities of building timber for their own or other companies' use.

For the purpose of impregnation the wood is placed in a large receptacle, into which the tar-containing gases are allowed to enter at a temperature of from 50 to 90 deg. Celsius. The high percentage of hydrogen possessed by this gas (about 50 per cent) renders it peculiarly suitable for impregnating purposes, as the hydrogen (due to its high molecular speed) is a much better medium for the conveyance of the impregnating substance than the steam generally employed with the usual processes. The tar-containing gases pass through the impregnating receptacles, the pressure therein being at the same time capable of being increased or placed under a vacuum; if desired, a higher pressure or a vacuum can be used alternately. According as to the method adopted, a shorter or longer period will be necessary for impregnation, and the selection of the actual method adopted will doubtless depend upon the nature of the wood to be treated and the purpose for which it is intended. Acceleration of impregnation is very often practicable by increasing the temperature of the gases.

The inventors have allowed for a possibility that the gases used under certain circumstances may not contain sufficient quantities of volatile tar oils, so that special means should be provided for enriching the gases therewith by evaporating or spraying liquid tar oil. The greatest saving effected by the process will in any case be due to the fact that the tar oil does not entirely fill up the cells of the wood, being merely penetrated by the tar-containing gases, which deposit a thin layer of this substance upon their walls. To use a homely illustration, the old process may be compared to filling a tub full of paint, whereas according to the new process merely the walls of the tub are brushed over with paint; the saving is obvious. It must not be assumed, however, that this is the end of the matter, as the gases penetrate right into the small cells in the very substance of the wood, and coat their surfaces as well.

It has already been proposed to evaporate suitable substances and impregnate wood therewith, and a trial was once made with resinous vapors obtained from resinous woods. In the present instance such a process would not be practicable, because large quantities of fuel would be required for the evaporation of the tar oil—and tar oil requires a temperature of 250 deg. Celsius for evaporation. Besides the question of expense, such high temperatures are also not advisable, as timber commences to suffer at a temperature of 130 deg. Celsius. Judging from the claims of the inventors and a careful perusal of the patent specification, we are of opinion that the new process should prove of special value, and meet with a fair meed of success.

VACUUM DISTILLATION.

MM. GIRARD, Truchon, and Laroche published, some time ago, the results of experiments in distillation in *vacuo*, made with glass vessels of about 2 gallons capacity. They have since repeated these experiments on a commercial scale, using an apparatus of metal with a boiler of nearly 70 gallons capacity. The distillations were effected in closed vessels, at temperatures ranging from 50 to 104 deg. F. The temperature of the condenser varied from the freezing point down to 4 deg. below the Fahrenheit zero, the latter temperature being obtained by means of freezing mixtures or refrigerating machines.

The mash or wort having been introduced, the entire apparatus is exhausted by means of an air pump. The still is then cut off from the vacuum chamber and distillation is commenced, with a moderate heat. The operation is repeated more or less often according to the alcoholic strength of the wort, the vacuum being restored when necessary by connecting the still with the vacuum chamber, after disconnecting the pump. The result is a strong spirit (80 to 98 per cent) which contains all the bouquet of the wort, and is remarkably free from impurities, especially from furfurol and the other products of decomposition which are generated in open fire distillation. The distillate is of uniform quality throughout the operation, so that it is not necessary to separate the first and last runnings, and the yield is consequently increased. Finally, the process is very rapid. With the apparatus mentioned, one hectoliter (22.5 gallons) of wort was distilled in one hour, yielding spirit of 90 to 98 per cent. In their article in the Moniteur Scientifique for August the experimenters give the results of analyses of various wines, infusion of pressed grapes, malt mash and beer, and the distillates and residues obtained from them by vacuum and by open fire distillation.

Juglandin Ink.—The green, fleshy meat that covers the fruit of the walnut tree contains, it is well known, an extractive substance which turns brown quickly if exposed to the air and colors the hands a deep brown. This substance yields a very durable and beautiful black ink, using 100 parts of green nutshells, 4 parts of iron vitriol, 1 part alum and 400 parts of water.

A MODEL ATOM.

HOW IT MAY BE CONCRETELY CONCEIVED.

LET a sphere of a certain radius (depending on the given circumstances) be described round each charged particle as center, and let the radii of these spheres be such that some of the spheres are in contact. The spheres may be called "spheres of interference," and the points of contact "nodes." The spheres associated with two oppositely-charged particles may be supposed to touch internally, and those associated with two particles carrying similar charges may be supposed to touch externally. A model atom may now be built up of spheres touching one another in this way. We shall suppose that there is one sphere surrounding all the others, which we shall call the atomic sphere. Within this sphere there may be other spheres which completely surround a number of others. Such groups will be called subatoms. As the electrons within the atom move about, we shall suppose that in general their spheres of interference adjust themselves so that the contacts are preserved. Such a motion may be called a "steady motion," and may be obtained by applying a continuous succession of conformal transformations to a given configuration of the spheres or set of spheres.

When an atom is in a normal state, we shall suppose that the outer shell contains either a ring of electrons the spheres of interference of which touch one another in succession, and also touch two other spheres (one internally and the other externally), or a system of electrons at the corners of a polyhedron, the spheres being now arranged so that each one touches all its neighbors and two other spheres as before. If the two extra spheres are kept fixed, the electrons can move round an ellipse, so that the contacts of the spheres are preserved, the radius of a sphere being at any time proportional to the distance of its center from the radical plane of the two fixed spheres (Steiner's porism). If now the mass to be associated with a given electron or sphere of interference belonging to the ring is inversely proportional to the square of the radius of the sphere, the total mass, kinetic energy, and position of the center of mass will remain invariable so long as all the contacts are preserved.

When an atom is ionized, we may suppose that there is one sphere missing from the ring if the charge be positive, and an extra sphere in contact with two spheres of the ring, but not belonging to the ring, if the charge be negative. If the number of degrees of freedom is calculated by allowing three for each electron and subtracting one for each contact or other geometrical condition, there will be a gain of one degree of freedom for each additional charge, whether it arises from the gain or loss of an electron. We may suppose that a line spectrum is emitted when a given arrangement of nodes or geometrical conditions is preserved, and a continuous spectrum when the geometrical conditions are violated. The group of infinitesimal conformal transformations seems the natural one for describing the kinematics of a system within a sphere. It may be built up from successive inversions with regard to spheres, just as the group of displacements of a rigid body may be built up from successive reflections in different planes. It should be noticed, however, that an even number of inversions are required to produce an infinitesimal change.

An inversion does not alter the type of contact of two spheres when the center of inversion is external to both; but when it lies in the space between two spheres, the type of contact changes, and the spheres become external to one another. This may be regarded as a kinematical description of a radio-active process, for a subatom may be thus brought outside the atomic sphere by a continuous succession of changes. According to this view, an atom would break up whenever one of the centers of inversion happened to lie within the atomic sphere. We suppose that in general the arrangement of spheres within the atom is not symmetrical. If, for instance, the atom forms part of a molecule, the field of force is not symmetrical, and there seems no reason why the arrangement of the electrons should be so.

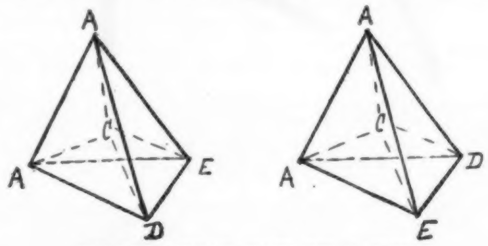
In the type of motion which is consistent with a constant value of the energy, the velocity of an electron belonging to the ring is directly proportional to the radius of its sphere of interference. This corresponds to a uniform motion in the symmetrical configuration, and may be derived from it by a conformal transformation. The assumptions made with regard to the mass of an electron, and the interference of radiation at the nodes, may be justified if the velocity of light within a sphere of interference is directly proportional to the radius.

The combination of a positive and negative ion may be pictured by supposing that the extra sphere belonging to the negative ion partly fits into the gap in the positive ion in such a way that it is in contact with two spheres belonging to the ring in the positive ion, and the atomic spheres of the two atoms are in contact. This would give three additional geometrical conditions. It should be noticed that the electrons would be nearer together close to the point of contact, so that the greater part of the mass would be concentrated round this point.

The connection between the number of degrees of freedom and valency is discussed in a paper which has appeared in the Memoirs of the Manchester Literary and Philosophical Society.—Harry Bateman in Nature.

CHEMICAL EFFECTS OF MAGNETISM.

ROSENTHAL, professor of physiology in Erlangen, has made a remarkable discovery that is intimately connected with the electromagnetic theory of light developed by Maxwell, and the magnetic rotation of the

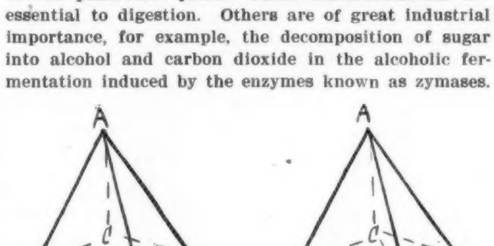


SYMMETRICAL CARBON ATOMS.

They can be made identical by turning either 180 deg. around an axis perpendicular to A A and E D.

plane of polarization, discovered by Faraday in 1846. From the fact that certain compounds which undergo hydrolysis (that is, absorb water and are resolved into simpler compounds) by the agency of enzymes or ferments, also rotate the plane of polarization of light, Rosenthal inferred a connection between electromagnetic phenomena and the structure of these compounds and the possibility of decomposing the latter by electromagnetic action.

Enzymes (ferments) convert albumen, fibrin, and other proteid substances into the simpler albumoses, peptones and amino-acids, starch and other polysaccharoses into monosaccharoses, and disaccharoses, such as dextrin, malt sugar, and grape sugar, and fats into fatty acids and glycerin. Each enzyme acts only on certain groups of substances, which it decomposes in a perfectly definite way. For example, starch is resolved into dextrin, maltose, and glucose by the diastase of malt and by the ptyalase of saliva. Albuminoids are resolved into albumoses, peptones, and amino-acids by the pepsin of the gastric juice and the trypsin of the pancreatic juice. These transformations are essential to digestion. Others are of great industrial importance, for example, the decomposition of sugar into alcohol and carbon dioxide in the alcoholic fermentation induced by the enzymes known as zymases.



ASYMMETRICAL CARBON ATOMS.

They cannot be made identical by turning in any way.

The manner in which these hydrolytic transformations are effected remains completely unknown. It is a remarkable fact, however, that the structural formula of every compound that is thus decomposed by enzymes contains at least one asymmetrical carbon atom. Now, according to the theory of Le Bel and Van't Hoff, the property of rotating the plane of polarization is also due to an asymmetrical carbon atom.

An atom of carbon, being quadrivalent, may be connected directly with four monovalent atoms or atomic groups. Atoms and molecules must occupy space of three dimensions, and the simplest assumption is that the carbon atom marks the center and its four associates are situated at the apices of a regular tetrahedron. If all four associates are alike (the four hydrogen atoms of methane, CH_4, for example), only one variety of the tetrahedron and the compound can be formed. This is equally true, though less obvious, when the carbon atom is combined with three atoms (or groups) of one kind and one of another, with two of one kind and two of another, or with two of one kind, one of a second, and one of a third kind. Two aggregations formed on any one of these plans may present themselves so as to appear unlike, but they can always be turned into positions in which their entire similarity is apparent.

If, however, the carbon atom is combined with four atoms or groups of four different kinds, these may be arranged according to either of two plans, which are related to each other as an object is related to its image in a mirror, and which cannot be brought into coincidence by turning them in any way. Such a carbon atom is called asymmetrical. The compound in whose formula it is found can exist in two isomeric varieties which, if they are separated, rotate the plane of polarization in opposite directions. Familiar examples are dextrose and levulose, the two varieties of glucose, or grape sugar.

The decomposition of these compounds, by the action of enzymes or otherwise, requires an accession of energy from without. In this respect it resembles the decomposition of certain other substances by heat and light. In the last-named case it is necessary for the substance to absorb rays of definite wave lengths. Hence, as the waves of light are believed to be essentially electromagnetic, it seemed not unlikely that some compounds, especially such as rotate the plane of polarization as a magnetic field does, might be decomposed by the action of magnetic waves.

Rosenthal placed such compounds in the interior of a hollow coil of wire and caused an interrupted or an alternating current to flow through the coil. Decomposition took place when, and only when, the frequency of interruption or alternation had a definite value, which was different for different substances. The products of decomposition were apparently identical with the products obtained by the action of enzymes. This was proved to be the case with starch, which under the influence of the oscillating magnetic field was gradually converted into soluble starch, dextrin, malt sugar, and grape sugar.

A constant magnetic field, produced by the passage of a direct current through the coil, had no effect on the compound.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

LIMIT TO NUMBER OF MARINE ORGANISMS.

A LIMIT to the earth's production of plants was expressed by Liebig in his "law of the minimum," according to which the production of vegetable matter must cease when any of the materials required for its production is entirely exhausted, that is, has been entirely transformed into vegetable matter. This law does not apply to the carbon dioxide of the atmosphere, which is the material most largely consumed in functional or vital, as distinguished from creative metabolism. Brandt has endeavored to extend Liebig's law to marine organisms, both animal and vegetable, and to prove that production is limited by the supply of nitrogen. Prof. Pütter opposes this theory, and shows that the water of the ocean contains, in the form of dissolved compounds, 1,850 times as much nitrogen as is contained in all marine organisms. Pütter asserts that the vital economy of the sea must be regarded from the viewpoint of vital or functional metabolism. He shows that the water of the ocean contains also, in combined and soluble form, 20,000 times the quantity of carbon that is contained in all marine organisms, and that, in all probability, these dissolved nitrogen and carbon compounds are produced by the "plankton" organisms, the functional metabolism of which is about 16,000 times as great as their creative metabolism. In other words, they store up, in growth and reproduction, only 1/16,000 part of the material which they consume.

Hence the picture of organic transformations in the sea shapes itself as follows: Immense quantities of carbon compounds are formed by algæ and returned to the water, probably after being greatly modified by bacteria adherent to the algæ. Large quantities of oxygen are set free by the agency of light, while the bacteria effect the disengagement of oxygen even in darkness.

All marine animals live, directly or indirectly, upon these dissolved carbon compounds, together with the comparatively infinitesimal mass of the plankton algæ themselves, employing these materials both in building up their bodies and as sources of energy for their vital activities. The material consumed for the latter purpose is many thousand times greater than the amount accumulated as animal substance.

MAN AS A MACHINE.

HUMAN ENERGY AND ITS EXPENDITURE.

BY DR. H. DEKKER.

IN 1748 the French physician La Mettrie published a book in which he attempted to prove that man is nothing but a machine, and the attempt has since been repeated by countless writers. But not to speak of finer differences between men and machines, no machine is born of or gives birth to another machine, grows, reproduces its worn-out substance, or is able to adapt itself to altered conditions. The function of a steam engine is to convert latent energy into motion. This statement is equally true of human muscles, but while the production of motion of one particular kind exhausts the powers of the engine, the human muscles can produce motion of many kinds and do a great many other things. Steam engines and similar machines are unconscious and imperfect imitations of the muscular machine, which is the natural transformer of energy. The artificial machine consumes coal, the natural machine consumes food, or, more specifically, glycogen, the starch-like substance which the liver manufactures from the food. In the words of Bruecke, a muscle is an engine built of albumen and stoked with glycogen. Both machines consume oxygen and generate heat.

A question of prime importance, both in the operation of machinery and in the activities of living beings, is this: How can a given task be accomplished with the smallest expenditure of energy? For expenditure of energy means expenditure of fuel or food. There are two ways in which economical utilization of energy may be sought: in the construction of the machine, and in its operation.

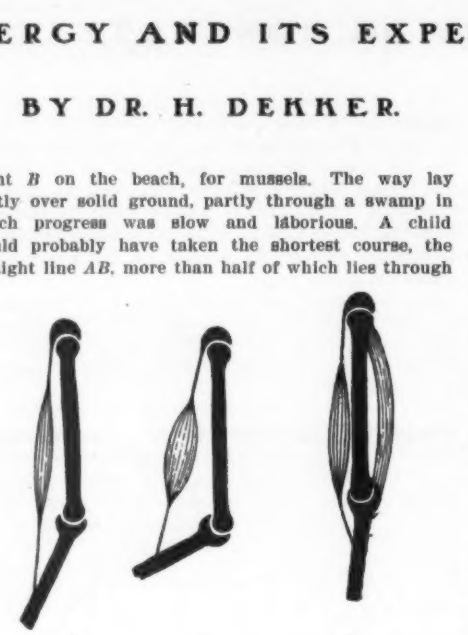
In general, the moving parts of machines are made as light as possible not only in order to save material and energy, but also in order to minimize the disturbing and disintegrating effects of vibration, but certain parts, such as the rims of fly wheels, are purposely made heavy in order to insure steadiness of motion through their inertia. The same principle finds expression in the thickening of the lower part of the leg bone in such fleet-footed animals as horses, camels, and ostriches. The bones are composed of a solid, but elastic, material, in which a saving is effected wherever this is possible. Their internal structure satisfies theoretical requirements more fully than that of the materials of artificial machines.

Nearly half the weight of the human body consists of muscles, which connect the bones and, by contraction, move them into various positions. In the best steam engines only one-tenth of the potential energy of the fuel is converted into mechanical work, but the muscles utilize in work from 34 to 55 per cent of the energy of the food—and probably much more, as the experiments which furnished these figures were performed with muscles removed from the body, not with living muscle, richly supplied with blood. The less the contraction of a muscle, the greater is its efficiency, or economy.

Most muscular movements are voluntary and may consequently be performed in an economical or a wasteful manner, at will. And we shall see that we are, even in health, very sparing of energy. Rheumatic persons are forced by the pain inflicted by violent movements, and convalescents and anæmic and neurasthenic persons are compelled by fatigue, to be positively niggardly. From the slow and cautious movements of such invalids we may learn how to execute a given movement with the smallest expenditure of energy. On the other hand, children are prodigal of energy, because their muscles need to be developed and educated by exercise.

A steam engine which is kept in good condition works hour after hour and day after day, always consuming the same quantity of coal in performing the same amount of work. This is not the case with the muscles, for the waste products of combustion accumulate in them and cause fatigue. This poison of fatigue is gradually washed away by the blood. In light and slow work it is carried off as rapidly as it is formed by the activity of the muscle, but in heavy, violent, or greatly prolonged labor it accumulates in the muscles and makes them less efficient as machines, so that they consume more fuel in performing a given amount of work. It is the sensation of fatigue that causes us unconsciously to select the easiest way of doing things—for example, to ascend a mountain by a winding, rather than by a straight, road, although we thus increase the total amount of work.

Haughton cites a very interesting case in his "Principles of Animal Mechanics." The women of a seaside village A (Fig. 4) were accustomed to go to a point B on the beach, for mussels. The way lay partly over solid ground, partly through a swamp in which progress was slow and laborious. A child would probably have taken the shortest course, the straight line AB, more than half of which lies through



1. 2. 3.

FIG. 1.—A MUSCLE AT REST. FIG. 2.—A MUSCLE IN ACTION. FIG. 3.—A PAIR OF "ANTAGONISTIC" MUSCLES.

the swamp, and an invalid would have chosen the course ACB, in which the distance to be traversed on soft ground is reduced to the minimum. The mussel gatherers selected the intermediate course ADB. Haughton measured the angles a and b, which the two parts of their course make with a line drawn at right angles to the edge of the swamp, and determined the speeds v and v^1, at which the women walked over

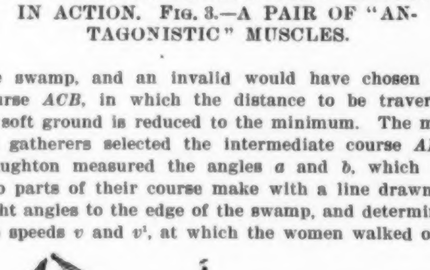


FIG. 4.—DIAGRAM OF THE MUSSEL GATHERERS.

the solid ground and the swamp. He found that these quantities satisfied the equation:

$$\frac{\sin a}{\sin b} = \frac{v}{v^1}$$

Now this is the fundamental law of the refraction of light. In other words, if the solid ground and the swamp are taken to represent two media in which the velocities of light are v and v^1, a ray of light going from A to B would follow the path taken by the women. This is the path by which the goal is

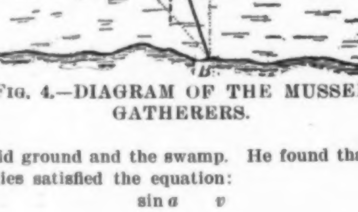


FIG. 5.—MAREY'S EXPERIMENT.

Before the operation. After the operation.

reached in the shortest time and also with the smallest expenditure of energy. The mussel gatherers found this path, not by mathematical reasoning, but by experience.

So, too, in work which involves movement of only part of the body, as in driving a nail, lifting a weight, etc., experience teaches us to select the easiest method. An inspection of Figs. 1 and 2 will make it evident that a muscle produces the maximum effect when the bones which it connects are at right angles to each other. Advantage is taken of this fact in bowling, exercising on the horizontal bars, etc.

There is another method of economizing muscular energy. When we undertake any task for the first time, we set to work, in addition to the muscles which must be used, other muscles, the activity of which is useless or even a hindrance. Thus we waste energy and quickly become fatigued. By practice, however, we learn to employ only the required muscles and so to reduce our exertion to a minimum. A child learning to write wastes its strength in gripping the pencil with unnecessary force. A boy learning to ride the bicycle holds the handle bars so firmly that his arms become tired sooner than his legs. By practice, the art of performing any action with the smallest exertion is acquired quite unconsciously. The guiding principle is the feeling of fatigue. No preliminary study of anatomy and mechanics would diminish the number of falls experienced while learning to ride the bicycle.

The movements of walking and running are too complex to be completely discussed here, but it may be observed that most persons who are not invalids waste much energy in raising the body unnecessarily with each step, and that in running exertion is saved by the bent positions of the knees and the body.

Every bodily movement calls a number of muscles into action, and the action of every muscle is opposed by another muscle, or group of muscles. The flexor and extensor muscles of the arm are examples (Fig. 3). When the arm hangs limp both the flexor muscle at the front of the upper arm and the extensor muscle at the back are soft, but both stiffen and contract when a weight is placed in the hand. The effect of this contraction is to hold the elbow joint in place. There are no loose joints in artificial machines. The joint of a pair of compasses, for example, is tightened by a special device, but no such devices are found in the joints of the body. In the construction of machines care is taken to produce certain motions as accurately as possible and to prevent "lost motion." For this purpose bearings, pivots, rails, and guides of various forms are employed. Motion of this character is called "constrained motion." But in the elbow joint precision of movement is attained, not by constraint imposed by solid bearings and guides, but by muscular tension. The same expedient is employed in machinery, but rarely, as it involves waste of energy. Is nature, then, wasteful of energy? No; for if all the motions of the body were constrained, a multitude of bony structures would be required which would overload the body and demand nourishment even when not in use. Hence it is more economical to secure precision of movement, when this is necessary, by muscular effort. Moreover, the tension joint permits a certain freedom of movement which is required for the thousand daily needs of the body, while the constrained machine is designed to execute a single movement with the greatest possible precision.

Two "antagonistic" muscles, such as the flexor and extensor of the arm, do not always work together, as in the case of the weight held with the arm pendent. When the arm is bent slowly both muscles act, for here, again, the elbow joint must be kept firmly in place, but when the arm is bent quickly the extensor muscle (at the back of the arm) does not come into action until the completion of the movement, which it arrests. The eyeball presents one of the few instances of constrained motion in the human body. The eye is turned outward and inward by two antagonistic muscles, but when it is turned outward by the contraction of the outer muscle, the inner muscle neither contracts to oppose the motion, nor remains passive, but spontaneously elongates. We see, then, that whenever muscular tension is required to steady a joint, at rest or in slow movement, the antagonistic muscles act together, but in rapid and in constrained movements the waste of energy involved in their simultaneous action is avoided.

The force exerted by a muscle increases with the number of muscular fibers which it contains, or with its sectional area. The tensile strength of human muscle is more than 140 pounds per square inch. The extent to which a muscle can contract is proportional to its length. It has been proved by anatomical study and experiment that the length and thickness of each muscle are exactly adapted to the work required of that muscle. If the work is increased, the muscle increases in proportion. Examples of this are seen in the arm of the blacksmith and the calf of the ballet dancer. If necessary, the length of the muscle increases as well as its thickness, and in some cases the length diminishes. For example, if a limb is shortened by the removal of a diseased portion of

bone and the union of the remaining parts, the muscles gradually decrease in length until they are again able to perform their normal functions.

In a similar manner the relative lengths of a muscle and its attached tendon may be altered by adaptation to changed conditions. The rotation of the forearm about its axis is effected by a flat muscle which runs obliquely from the elbow to a point on the radius (the smaller bone of the forearm). When this rotation has become limited through a stiffening of the elbow joint or otherwise, so that the whole length of the rotating muscle can no longer be utilized, part of it becomes converted into tendon. Marey removed part of the heel bone of a rabbit and attached the stump to the tendon of the muscle of the leg. The muscle now acted on a shorter lever and consequently was required to exert a greater force, but to contract to a smaller extent, than before the operation. The consequence was that the muscle became shorter and thicker, and its tendon increased in length (Fig. 5). The dimensions and shape of every muscle and the length of its tendon are adapted to its work with a perfection never attained in artificial machines.

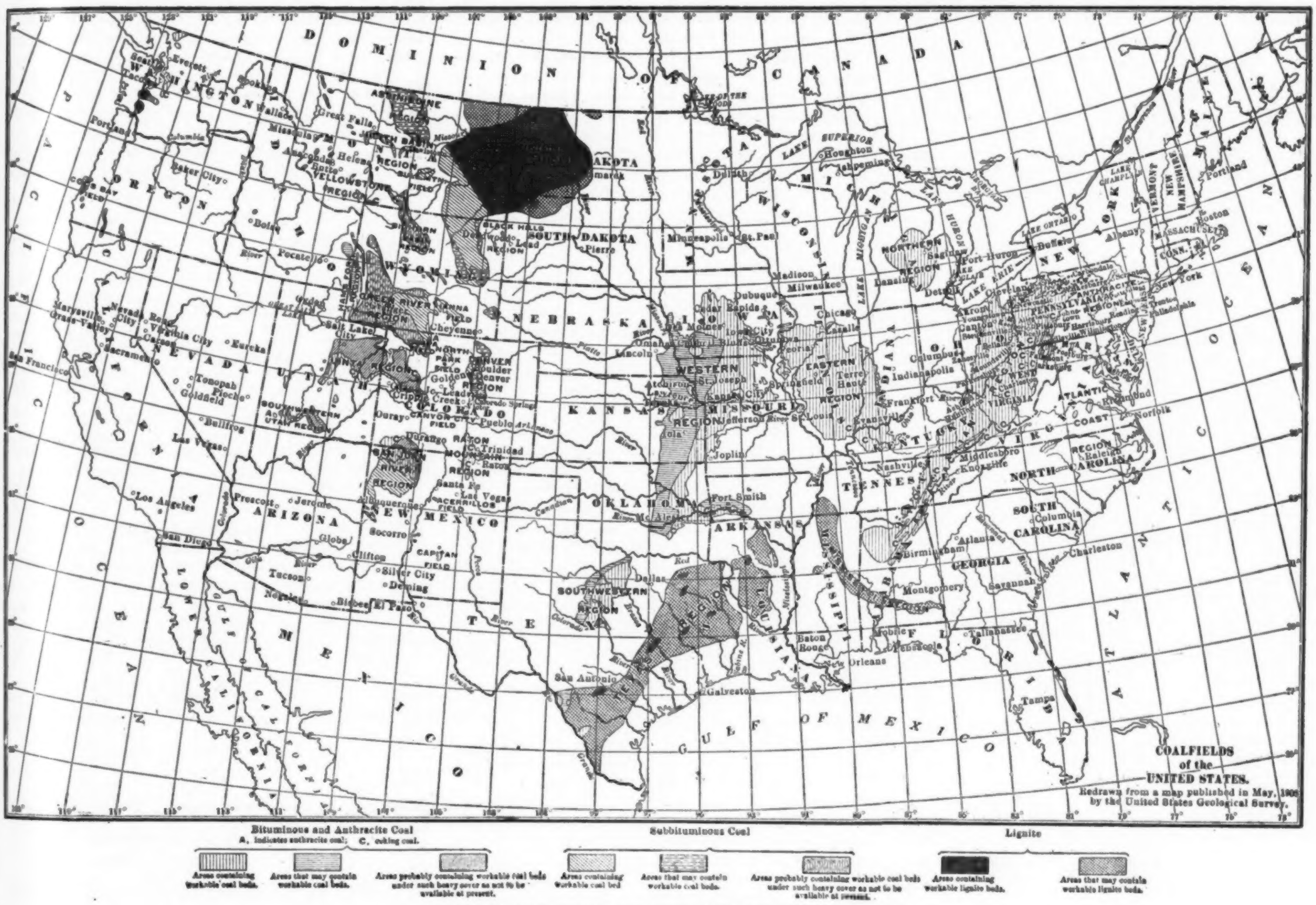
We have seen that the muscles utilize more than half the energy supplied to them and that they work most economically when they contract but slightly. We do not know how the chemical energy of glycogen (and possibly also of fat) is transformed into external work. We know, however, that five times as much blood flows through a muscle at work than flows through the same muscle at rest, and that the working muscle consumes 20 times as much oxygen and 35 times as much carbon as the idle muscle consumes in the same time. We know also that heat is produced as well as work. Heidenhain has discovered that, within certain limits, the work performed by a muscle increases with the amount of work demanded of it, and that less heat, relatively, is developed by intense than by moderate muscular activity. This is an admirable provision for economy in heat and energy.

In everything pertaining to the body, its external form, the adaptation of its members for the performance of work, the internal construction of the muscular machine, and the operation of all its parts, we find examples of economy and fitness which the machine designer might study with profit.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Kosmos.

THE COALFIELDS OF THE UNITED STATES.*

2,000 BILLION TONS OF COAL AVAILABLE.

THE accompanying map, redrawn from one prepared by the United States Geological Survey, shows the coalfields of the United States as their outline is now known and the kinds of coal they contain. Up to the present time it has not been possible to prepare so accurate a map, on account of lack of data regarding the shape and extent of many of the western coalfields and the quality of their coal, but during the last few years a large amount of such information has been obtained in connection with the classification and valuation of coal land in the public land States of the West. In carrying on this work the Geological Survey has mapped most of the important coalfields and has tested many of the coals, so that information now at hand seems to be fairly complete. There is still, however, considerable uncertainty regarding the extent and value of some fields containing low-grade coal or lignite. This is particularly true of the lignite fields of the Gulf province, except those of Texas, in which there has been considerable development and exploitation. Little information is available regarding the lignite areas of South Dakota and the lignite and sub-bituminous fields of the Fort Union region, in eastern Montana. The extent and value of the coal beds of the Assiniboine region, in north central Montana, as well as those of the isolated Tertiary lake basins of the mountainous parts of the State, are also matters of speculation.



THE COALFIELDS OF THE UNITED STATES.

Information as to the extent, the value, and even the existence of the coalfields of the Pacific coast is very meager. California and Oregon probably have greater coal resources than those now known, but the beds in these States are generally of low-grade coal and are undeveloped. The fields of Washington doubtless embrace a much greater area than that shown on the map, but they are so covered by glacial gravel and heavy timber that it is impossible to determine their extent. Probably many of the areas represented on the map are really connected in a broad belt of coal-bearing rocks along the west slope of the Cascade range.

Little is known regarding the occurrence of coal or the extent of the fields in southern and southeastern Utah, where there are probably many areas of coal-bearing rocks but little coal of commercial importance.

On this map, for the first time, an attempt has been made to represent the coal in the deep basins or synclines of the Rocky Mountain States, where there is every reason to suppose that coal exists, although it is so deeply covered by later sediments as to be accessible with great difficulty if at all. The most important of these basins are the San Juan River basin of New Mexico and the Colorado, the Uinta basin of Colorado and Utah, the Green River basin of Wyoming and Colorado, and the Bighorn basin of Wyoming. None of the basins and troughs of the eastern part of the country is like these western basins, except possibly, the central part of the Appalachian trough in West Virginia and a part of the Michigan basin, but both of these are comparatively shallow, and all of the coal they contain may be regarded as accessible.

CHARACTER OF THE COALS.

From a commercial standpoint the most important feature of the map is the distinction between the various grades of coal. The Geological Survey recognizes the following six classes: (1) anthracite, (2) semi-anthracite, (3) semi-bituminous, (4) bituminous, (5) sub-bituminous (black lignite), and (6) lignite.

In almost all the western fields there is a transition from low-grade to high-grade coal in the direction of the principal mountain uplift. In the San Juan River region the coal changes from sub-bituminous in the southern part to bituminous on the flanks of the San Juan Mountains, the transition in the field being gradual and not sharp. In the Uinta basin the coal is bituminous, and of fairly uniform quality in all parts of the rim. In the Green River basin most of the coal is sub-bituminous, but some around the

* Engineering and Mining Journal.

Rock Springs dome in Wyoming is bituminous, as is the lower coal in the eastern part of the Yampa field in Colorado. In the Bighorn basin the coal does not differ much in composition from place to place; in general it is better on the southwestern side of the basin, but even there it hardly reaches the grade of bituminous. In the Fort Union region there is a decided change from the brown lignite of the North Dakota portion to the sub-bituminous coals of the Sheridan district in Wyoming. This change is gradual, affecting a wide region in eastern Montana.

GEOLOGIC AGE OF THE COALS.

The geologic age of the coal-bearing rocks of the United States ranges from Carboniferous in the eastern and interior provinces to Miocene (Tertiary) in California and other places on the Pacific coast. In a very general way the quality of the coal varies with the geologic age of the coal beds, but there are so many exceptions that such a generalization has little value.

In the main, the best coals of the country are of Carboniferous age and are found in the anthracite and Appalachian fields; also in the northern, eastern, western, and southwestern regions of the eastern and interior provinces. In this broad area the coals of higher grade occur in the anthracite region, along the eastern front of the Appalachian region, and in the Arkansas fields of the western region near centers of great disturbance and mountain building.

In the Atlantic coast region a number of basins of Triassic rocks contain workable beds of coal. In the early days of the colonies these were of great importance, but later they fell into disuse and are now practically abandoned.

The lignites of the Gulf province are of Eocene (Tertiary) age and are of low grade except in the vicinity of Laredo, on the Mexican line. Those of the Eagle Pass region are of better grade and are decidedly older, belonging to the Cretaceous system.

In the Rocky Mountain and Northern Great Plains provinces the coal-bearing rocks range in age from Lower Cretaceous to Eocene (Tertiary). The former other fields of Colorado and Utah almost all the coal beds so far known are of this age. In Wyoming, Upper Cretaceous coals are present in the Hams Fork, Green River and Bighorn Basin regions, and in the Hanna and other smaller fields. In Montana they are limited largely to the Yellowstone and Assiniboine regions and to the Bridger field, in Carbon County.

TONNAGE (SHORT TONS) BY PROVINCES AND ACCESSIBILITY.

Province.	Area in Square Miles.	Original Coal Supply.		Easily Accessible Coal Still Available.
		Amount Easily Accessible.	Amount Accessible With Difficulty.	
Eastern	70,0[illegible]	336,673,000,000	8,000,000,000	336,870,000,000
Interior	144,064	406,667,000,000	91,000,000,000	404,728,000,000
Gulf	84,300	13,045,000,000	10,045,000,000	13,031,000,000
Northern Great Plains	103,564	821,793,000,000	489,000,000,000	821,784,000,000
Rocky Mountains	92,3[illegible]	414,740,000,000	574,380,000,000	414,382,000,000
Pacific Coast	1,[illegible]	11,109,000,000	10,900,000,000	11,027,000,000
Total	496,776	2,004,018,000,000	1,183,225,000,000	1,993,800,000,000

TONNAGE (SHORT TONS) BY GRADES OF COAL AND ACCESSIBILITY.

Kind of Coal.	Area in Square Miles.	Original Coal Supply.		Easily Accessible Coal Still Available.
		Amount Easily Accessible.	Amount Accessible With Difficulty.	
Anthracite and bituminous	250,531	1,257,766,000,000	305,730,000,000	1,247,672,000,000
Sub-bituminous	97,634	356,707,000,000	293,150,000,000	356,594,000,000
Lignite	148,609	389,545,000,000	554,045,000,000	389,534,000,000
Total	496,776	2,004,018,000,000	1,153,225,000,000	1,993,800,000,000

The great expanse of coal of the Fort Union region of North Dakota, South Dakota, Montana and Wyoming is of Eocene (Tertiary) age. Coals of the same age occur in the Bull Mountain field, on Musselshell River, and in the Red Lodge field, on the southern boundary of Montana. Eocene coals also occur in the Green River basin east of Rock Springs, in the center of the Hanna field, and in certain parts of the Hams Fork region, in Wyoming.

The mountain basins in the western part of Montana, as well as some in Idaho, are of Tertiary age, although few of them have been mapped, and the coals of only a few have been examined.

In the Pacific coast province all the coals are of Tertiary age, though some of them have been locally metamorphosed into anthracite by intrusions of igneous rock. The Washington coals, as well as those of coal yet remaining in the ground, and no one knew whether or not the present growing consumption would continue indefinitely; consequently there has been a general feeling that the supply of coal in the United States is inexhaustible, and that the present generation need give no thought to this troublesome question.

The uncertainty regarding future consumption still exists, but data are now at hand, except for certain little-known fields of the West, that will afford the basis for a fairly trustworthy estimate of the tonnage of coal yet remaining. These western fields, however, except those of Washington, are of small extent, and the uncertainty as to their content has little effect on the aggregate amount.

The latest available estimate of the total original tonnage of the coalfields of the United States, exclusive of Alaska, was made by the Geological Survey in 1906. This estimate gave 2,200 billion short tons as the total original content of the fields, but was confessedly made without adequate information, since little was known at that time regarding many of the most important fields of the western States. With the increased information at hand regarding these fields, it seems opportune now to present an estimate considerably larger than that made two years ago. Part of this difference is due to increase in information, and part to an increase in the limit of depth to which coal beds may be worked.

The limit of workable depth in the estimate here given is based on actual mining conditions abroad, especially in Belgium. This limit is 3,000 feet for coal and 1,000 feet for lignite. Twenty inches is regarded as the minimum minable thickness of bed for coal and 3 feet for lignite.

The table shows the size of areas represented on the map, in square miles; the kind of coal; the production in 1906; the total production to date, including estimate of production for 1907, to which is added 50 per cent for waste in mining; the estimated original tonnage; and the estimated amount remaining in the ground at the present time.

Areas, Estimated Tonnage, and Production of the Various Coal-fields of the United States.

[A = Anthracite. B = Bituminous. S = Subbituminous. L = Lignite.]

State and Field.	Area in Square Miles: Containing Workable Coals.	May Contain Workable Coals.	Coal Under Heavy Cover.	Kind of Coal.	Estimated Original Coal Supply in Short Tons. Coal Both Easily Accessible and Accessible with Difficulty.	Production in Short Tons: 1906.	Total to January 1, 1908, Including Waste.
Alabama:							
Warrior and Plateau fields	7,845	......	......	B	63,513,000,000	11,301,993	......
Cahaba field	325	......	......	B	2,994,000,000	1,635,907	......
Coosa field	260	......	......	B	2,396,000,000	170,063	......
Lignite field	......	6,000	......	L	......	......	......
Total	8,430	6,000	......	......	68,903,000,000	13,107,963	247,000,000
Arizona	30	......	......	B	60,000,000	......	......
Arkansas:							
Bituminous field	1,584	......		B	1,797,000,000	1,934,673	......
Lignite field	100	5,900		L	90,000,000	......	......
Total	1,684	5,900	......	......	1,887,000,000	......	36,000,000
California	500?	......		S, B	1,000,000,000	25,290	7,000,00
Colorado:							
Denver region	600	3,700	......	S	13,590,000,000	1,544,776	......
Durango field	1,380	......	520	B, S	21,428,000,000	177,718	......
North Park field	20	480	......	S	453,000,000	1,300	......
Trinidad field	1,080	......	......	B	24,462,000,000	6,572,673	......
Uinta region	6,000	......	......	B, A	271,810,000,000	1,143,310	......
Yampa field	700	......	2,300	B, S, A	39,639,000,000	5,407	......
Scattered fields	350	......	......	B, S	388,000,000	666,034	......
Total	10,130	4,80	2,820	......	371,770,000,000	10,111,218	169,000,000
Georgia	167	......	......	B	933,000,000	353,548	12,000,000
Idaho	200	1,200	......	S, B	600,000,000	5,882	......
Illinois	35,600	......	......	B	240,000,000,000	38,434,363	968,000,000
Indiana	6,500	......	......	B	44,169,000,000	11,895,252	239,000,000
Iowa	12,560	5,640	......	B	29,160,000,000	6,798,609	212,000,000
Kansas	3,100	15,780	......	B	7,022,000,000	6,423,979	136,000,000
Kentucky:							
Eastern Kentucky	10,270	......	......	B	67,787,000,000	3,768,651	......
Western Kentucky	6,400	......	......	B	36,241,000,000	5,884,996	......
Total	16,670	......	......	......	104,028,000,000	9,653,647	184,000,000
Louisiana	8,800	......	......	L	......	......	......
Maryland	455	......	......	B	8,044,000,000	5,108,539	221,000,000
Michigan	11,000	......	......	B	12,000,000,000	1,473,211	21,000,000
Mississippi	7,500	......	......	L	......	......	......
Missouri	16,700	6,300	......	B	40,000,000,000	3,983,378	146,000,000
Montana:							
Fort Union region	32,300	6,100	......	L, S	279,500,000,000	......	......
Bull Mountain field	754	......	......	S	6,560,000,000	......	......
Red Lodge and Bridger fields	47	100	......	S	2,000,000,000	557,148	......
Judith Basin region	516	2,500	......	B	2,000,000,000	1,058,763	......
Assiniboine region	......	8,000	......	S	10,000,000,000	13,550	......
Yellowstone region	450	......	......	B	3,000,000,000	200,460	......
Scattered fields	......	875	......	S, L	......	......	......
Total	34,067	17,575	......	......	303,060,000,000	1,829,921	37,000,000
New Mexico:							
Raton field	1,360	......	......	B	30,805,000,000	1,292,241	......
San Juan region	11,600	......	5,000	S	131,375,000,000	604,517	......
Scattered fields	375	......	......	B, A, S	1,600,000,000	67,955	......
Total	13,335	......	5,000	......	163,780,000,000	1,964,713	33,000,000

State and Field.	Area in Square Miles: Containing Workable Coals.	May Contain Workable Coals.	Coal Under Heavy Cover.	Kind of Coal.	Estimated Original Coal Supply in Short Tons. Coal Both Easily Accessible and Accessible with Difficulty.	Production in Short Tons: 1906	Total to January 1, 1908, Including Waste.
North Carolina	60	......	......	B	200,000,000	......	1,000,000
North Dakota:							
Western fields	31,240	3,900	......	L	500,000,000,000	317,542	......
Turtle Mountain field	......	360	......	L	......	......	......
Total	31,240	4,260	......	......	500,000,000,000	317,542	4,000,000
Ohio	12,660	......	......	B	86,628,000,000	25,552,950	739,000,000
Oklahoma	10,000	......	......	B	79,278,000,000	2,924,427	60,000,000
Oregon	230	......	......	S	1,000,000,000	109,641	2,000,000
Pennsylvania:							
Anthracite region	480	......	......	A	21,000,000,000	71,282,411	......
Bituminous fields	14,200	......	......	B	112,574,000,000	129,293,206	......
Total	14,680	......	......	......	133,574,000,000	200,575,617	5,652,000,000
South Dakota	2,000	4,000	......	L	10,000,000,000	......	......
Tennessee:							
Bituminous fields	4,400	......	......	B	25,665,000,000	5,766,690	......
Lignite fields	1,000	......	......	L	......	......	......
Total	5,400	......	......	......	25,665,000,000	5,766,690	126,000,000
Texas:							
Bituminous fields	8,200	5,300	......	B	8,000,000,000	839,985	......
Lignite fields	2,000	53,000	......	L	23,000,000,000	472,888	......
Total	10,200	58,300	......	......	31,000,000,000	1,312,873	22,000,000
Utah:							
Uinta region	9,990	......	......	B	150,970,000,000	1,701,674	......
Southwestern Utah region	3,140	1,500	......	B, A	45,438,000,000	......	......
Scattered fields	......	500	......	B, S	50,000,000	70,877	......
Total	13,130	2,000	......	......	196,458,000,000	1,772,551	28,000,000
Virginia:							
Southwestern fields	1,550	......	......	B	21,000,000,000	4,205,019	......
Brushy Mountain fields	200	......	......		900,000,000	49,860	......
Richmond fields	150	......	......	b	600,000,000	......	......
Total	1,900	......	......	......	22,500,000,000	4,254,879	86,000,000
Washington	1,100	......	......	B, S	20,000,000,000	2,864,926	64,000,000
West Virginia	17,000	......	......	B	231,039,000,000	87,791,580	650,000,000
Wyoming:							
Fort Union region	11,530	3,060	......	S	174,600,000,000	1,091,499	......
Bighorn Basin region	905	430	2,830	S	1,000,000,000	5,451	......
Hanna field	1,435	240	290	S	33,000,000,000	450,636	......
Green River region	4,855	1,350	20,750	B, S	199,152,000,000	2,122,253	......
Hams Fork region	1,073	960	115	B, S	16,000,000,000	2,078,772	......
Black Hills region	320	......	......	B	133,000,000	385,383	......
Scattered fields	450	200	......	S	200,000,000	......	......
Total	20,568	6,240	23,985	......	424,085,000,000	6,133,994	116,000,000
Total for United States	327,596	137,375	31,805	......	3,157,243,000,000	414,157,278	10,218,000,000

THE COALFIELDS OF THE UNITED STATES.

occur in the Great Falls and Lewistown fields of the Judith basin, central Montana, and in the Black Hills region, Wyoming. These rocks are of Kootenai age, the age of the rocks of the Crows Nest Pass and other important fields of Alberta.

Upper Cretaceous rocks carry most of the coals in the San Juan River and Raton Mountain regions of southern Colorado and New Mexico, as well as those in most of the scattered fields of New Mexico. In the the Coos Bay field in Oregon, are Eocene; those of west-central California—at least those in Stone Cañon, Monterey County—are Lower Miocene.

ESTIMATED TONNAGE OF THE VARIOUS FIELDS.

During the last few years considerable attention has been given to the need of conserving the mineral fuels of this country for the use of future generations. Few persons were in possession of data that would enable them to make an estimate of the amount of

The figures given show that the area of the more accessible coal fields of the United States is about 327,000 square miles, and that they carry an estimated content available for future use of nearly 2,000 billion tons. The rate of consumption cannot be predicted with certainty, but if the rate of increase that has held for the last fifty years is maintained, the supply of easily available coal will be exhausted before the middle of the next century.

THE ART OF MAKING ALLOYS.*

SOME SUGGESTIONS OF PRACTICAL IMPORTANCE.

BY PERCY LONGMUIR.

AN alloy may be defined as a substance possessing the general physical properties of a metal, but consisting of two or more metals or of metals with non-metallic bodies in intimate mixture, solution, or combination with one another, forming, when melted, a homogeneous fluid. Examples of the union of a metal with a non-metallic body are found in the well-known carbon-iron alloys, and of the union of two or more metals in the various brasses and bronzes. An alloy may be formed by diffusion of one substance into another; thus, under certain conditions carbon will diffuse into solid iron and one metal may be made to pass into another. In some cases compression of the constituent metals when in a fine state of division will result in the formation of an alloy. However, in practice all foundry alloys are produced by fusion of the constituent metals. This may be expected in gas, coal, coke, or oil-fired crucible furnaces, or in gas or coal-fired reverberatory furnaces. As a rule, the coke-fired crucible furnace is employed for small quantities, and the coal-fired reverberatory furnace for large quantities. Special mention should be made of the non-crucible oil melting furnaces. Occasionally foundry alloys are a product of the bottom or side-blown Bessemer converter, and of the open-hearth steel-melting furnace.

Success in the production of alloys can only be attained by practical experience and personal contact with the difficulties encountered. There is no royal road, and very little guidance can be given on paper. Further, a distinction must be drawn between the production of laboratory and commercial alloys. Determining conditions, often ignored in the first case, have a very decisive bearing in the second one, in which the alloys have to meet competition and service conditions. In other words, a commercial alloy must not only yield its maximum properties, but must also be produced under conditions enabling it to compete with others on the market.

The metals which enter into the constitution of alloys are worth consideration. Taking commercially pure metals, cast in sand and untreated, the values in the accompanying table have been obtained from tensile tests.

These results are not particularly striking, and they emphasize the fact that commercially pure metals, cast in sand molds, and untreated, are of comparatively little utility in the foundry. Of course, certain of the metals, such as copper, nickel, aluminium, lead, and zinc, are used in a state of commercial purity for specific purposes; but the total weight of metals so made is not at all large. The properties of the metals undergo vast changes by working, such as forging,

	Mechanical Properties		
	Maximum Stress, Tons per Sq In.	Elongation, Per Cent on 2 Ins.	Reduction, of Area, Per Cent.
Annealed iron..	20.0	40.0	60.0
Nickel	16.25	4.5	9.75
Aluminium	7.0	6.0	10.0
Copper (chill)..	10.0	25.0	26.0
Copper (sand)..	8.1	9.2	10.0
Tin	2.0	30.0	
Lead	1.5	36.0	
Zinc	1.5		

rolling, or drawing, and also by treatment, such as annealing, quenching, and the like. However, such processes are beyond the range of normal foundry practice. The object of alloying lies in a desire to modify the properties or the cost of the initial metals. The desired modification may be simply one of color in the resulting alloy; on the other hand, it may be a change in mechanical, electrical, or chemical properties. In most cases the full modification may be obtained from the alloys in the cast condition; in other cases annealing or treatment may be necessary—a feature exemplified in the alloys of iron.

As a marked example of changes due to alloying, we may take that of electrical resistance. The resistivity of ordinary iron is 9.8 microhms per cubic centimeter. If increasing contents of nickel are alloyed with this iron we have:

Per Cent Nickel Added.	Per Cent Microhms per Cu. Cm.
0.00	9.8
4.25	29.1
4.95	39.3
6.42	42.8
19.9	75.5
31.0	86.5

These values represent the effect of one metal alloyed with another. If we take a triple alloy, say iron + 14.5 per cent Ni, + 5 per cent Mn, the resistivity is 83—a value practically equal to that of 31 per cent nickel-iron alloy. Incidentally this is also an illustration of the value of alloying in reducing production costs without impairing quality. While on this subject, one example may be taken from a Cu, Ni, Zn alloy. Thus, ordinary German silver gives a resistivity of about 21 microhms; the same German silver alloyed with 1 to 2 per cent tungsten gives a resistivity of 41—nearly double that of the original alloy.

Another direction in which alloying is followed for its effect on physical properties lies in influencing solidification. As a rule, the solidification point of an alloy is lower than the mean of its constituents, and advantage is taken of this in the production of readily-fusible metals. The opposite, in which an increase in solidification temperature occurs, is not so familiar, nor yet much sought after. Yet this has a decided industrial value. Just one example may be given. Some of the steam-metal alloys contain a eutectic which solidifies at a comparatively low temperature. It therefore follows that on heating up from the cold this eutectic softens at a comparatively low temperature. Assuming the alloy to be in the form of a valve body, then on attaining a certain temperature this eutectic becomes pasty, and therefore porous. We have a solid valve body, containing areas porous to high-pressure steam. This is just the merest mention of a phase which has attracted attention in scientific circles. Long ago certain practical men discovered that the addition of a small amount of arsenic to steam-metal resulted in an alloy capable of giving better working life when exposed to heats somewhat above normal steam heat.

This addition of arsenic raises the temperature at which the eutectic softens, and therefore assists steam tightness at higher temperatures than would be possible in its absence. This is just one example of the value of raising a solidification point; no doubt many others will occur.

Alloying is also followed for its influence on chemical properties, chiefly in the direction of increasing the resistance offered to the solvent action of acids. Acid-resisting metals are chiefly remarkable for either a high content of lead or antimony. Cast irons are alloyed with silicon in order to achieve the same end.

Turning from the general to the particular, the most striking series of alloys are those known as steel. Ordinary steel castings are essentially alloys of iron and carbon, carbon being, as a rule, the only variable. The influence of this variable, starting with pure iron, is as follows:

Carbon.	Maximum Stress, Tons per Sq. In.	Elongation, Per Cent on 2 Ins.	Reduction in Area, Per Cent.
0.08	20.0	40.0	60.0
0.28	28.0	33.0	45.0
0.51	35.0	22.0	27.0

Good quality cast iron, 12 tons per square inch, no elongation.

The three steels given represent surface-blown material, obtained in the usual way of commerce; the values given are high, and possibly somewhat above the average. However, it will be noted that a rise in carbon is followed by a rise in breaking load, and a fall in elongation and reduction of area.

Iron-carbon alloys with a third element are for the most part similar to forged steels. However, in the foundry special steels are at times produced, as exemplified in the production of certain types of shell, switch tongues, crossings, and the like. The following tests give results obtained from a series of nickel steels of almost constant carbon and manganese, but varying nickel. The steels were heated to 800 deg. C. and slowly cooled.

	Ni.	Mn.	Elongation, Per Cent.
	0.0	38.5	15.5
	1.2	43.2	14.2
	2.15	42.8	17.7
	4.25	43.5	13.1
	4.95	56.1	14.3
	6.42	57.5	6.2
	7.95	74.0	4.5
	12.22	71.2	6.2
Highest	15.98	76.5	4.0
Lowest	19.91	26.7	14.3

These results are possibly not of great industrial value; however, they give a very good index of the influence of a third element. The addition of a third element does not always confer regular increases or decreases in properties. A good example of this occurs in the now well-known manganese steels. As Hadfield showed in 1888, gradual increments in manganese do not give regular increases in properties. Thus, up to 1 per cent Mn, little effect follows. Beyond 1 per cent brittleness is exhibited, and from 4 to 6 per cent the alloy may be powdered under a hand hammer. At about 9 per cent manganese ductility returns, and at about 13 per cent a material of entirely new properties is obtained. This manganese steel resists abrasion remarkably well, is almost unmachinable, and is toughened by dipping it at a full yellow heat into cold water.

Manganese steel forms possibly one of the best examples of alloying current in the metallurgy of steel castings. It embodies control of composition and after treatment. So far as steel castings are concerned the two features, composition and treatment, must be recognized. Investigation on these lines, and from a purely foundry point of view, will lead to considerable increase in our knowledge of steel alloys.

* From a paper read before the Lancashire Branch of the British Foundrymen's Association.

TO PREVENT CRYSTALLIZATION OF ELECTROLYTIC COPPER.

WHEN solutions of copper obtained by leading ores, etc., are electrolyzed with the aid of insoluble anodes the copper deposited on the cathodes is crystalline in structure and usually contains large tetrahedral or octahedral crystals. The crystallization must be attributed to the oxygen liberated at the anode for it does not occur in the electrolytic refining of copper when the impure metal forms the anodes. Agnolucci, endeavoring to prevent the crystallization, finds that little advantage is gained by using anodes which are porous or easily oxidized, as porous graphite soon loses its porosity by absorbing matter from the solution and spongy lead is still less effective. The counter-electromotive force of polarization at the anode constitutes another objection. Very satisfactory results, however, are obtained by employing sulphurous anhydride to absorb the nascent oxygen. The electromotive force required is diminished, and the deposit of copper is smooth, compact and non-crystalline.

Sulphurous acid is a cheap substance in copper works, where it is evolved in great volumes in washing the ore, etc. The anodes should be as little subject to polarization as possible. Platinum and iridium being excluded by their cost, the practical choice is between lead and carbon, and as lead is oxidized to some extent, it is best to use carbon, in the form of graphite, which undergoes very little oxidation.

THE VOLATILITY OF SILICA.

THE industrial employment of very high temperatures is continually increasing, and the temperatures attained in electric, oxyhydrogen and oxyacetylene furnaces have shown the necessity of seeking new fire-resisting materials. Silica was long regarded as infusible, but Cramer, employing the oxyhydrogen flame in 1892, and Moissan, employing the electric furnace in 1893, succeeded in melting and even volatilizing silica in crucibles of carbon, which insured the presence of a reducing atmosphere. In these conditions, according to Stein's experiments in 1907, silica becomes pasty at 2,900 deg. F. and fluid at 3,200 deg. F., above which point it is rapidly volatilized. In an oxidizing atmosphere Hirsch fused quartz but could not volatilize it.

Hirsch used an electric resistance furnace composed of two concentric cylinders of very refractory porcelain, with the space between them filled with carbon, in which the electrodes were imbedded. The substance to be fused was placed in the inner tube, through which a gentle blast of air was blown. Although quartz was not volatilized, a partial volatilization of the silica of certain varieties of clay was observed at very high temperatures. The observation had already been made by Cramer in 1897.

SUBSTITUTE FOR INDIA RUBBER.

BY a process recently patented by W. H. Brownlow, of Canada, a substitute for India rubber is made by combining glue, molasses and glycerine with a small quantity of tar. 360 parts of glue, 360 parts of molasses, 120 parts of glycerine, and 1 part of tar are heated together by steam or hot water. The addition of tar makes the mass tough, flexible and very similar to India rubber.

AERONAUTICAL AND MILITARY SCIENCE.*

MILITARY TACTICS AND THE DIRIGIBLE AIRSHIP.

Every new invention of military science necessitates changes in tactics, but tactical and technical improvements develop very differently. The latter are often extensive and revolutionary, but tactical progress is always slow and gradual. Hence the revolution in tactics so often prophesied as the result of a new invention never takes place.

In regard to the dirigible airship tacticians maintain their habitual caution and reserve, but few doubt that the airship is destined to become an auxiliary more valuable than a mere scout. It will, like cavalry, be employed in gathering every sort of information that may have a strategical value. The new invention is not yet freed from certain technical defects, of which the most serious are its small radius of action and its dependence upon selected and prepared landing places. The latter consideration is of especial importance in the case of airships of the rigid type.

Nevertheless, the field of operation of the airship is far more extensive, both in time and in space, than that of large bodies of cavalry. In space it covers the whole field of active hostilities, and in time it is not restricted by the necessity of awaiting a declaration of war. The airship can be employed whenever the course of political events and the imminence of a diplomatic crisis appear to justify the collection of detailed information of affairs beyond the frontier. Whether or not such action would be regarded as "unfriendly" must here be left an open question. Probably the next Hague conference will decide whether this employment of airships is an act of war or merely an allowable extension of the officially recognized diplomatic and military service of information.

The moment after war is declared the airship becomes an active scout. Battles between airships, however, will probably be of very rare occurrence, even if many airships are employed on each side. The function of a scout is to watch and inform, while avoiding all useless contact with the enemy. Such contact can be avoided more easily by airships than by cavalry, which is required to guard as well as to watch, and is hampered by topographical conditions.

The first extensive strategical reconnaissance by airships, working singly or in squadrons, will furnish a peculiar and totally new picture of the field of war. Yet it is not likely to cause a sudden revolution in tactics. Military engineers will endeavor to devise effective means of keeping airships at a distance. If this endeavor fails, each combatant will simply have to make the best of the fact that his initial operations are known to the enemy. Each side will have an additional means of information, so that neither will gain any advantage.

The conditions change when the armies are in the field and actual conflict is imminent. Then the airship may be required to perform offensive operations. The possibility that an unscrupulous enemy may use his airships for such purposes (destroying railway tunnels, for example) even before war had been declared must be met by guarding all points of strategic importance in time of peace.

In many cases, lines of communication can be interrupted and kept closed more easily and effectively by airships than by cavalry, which is usually compelled to make long detours. For the present, however, the performance of such duties is complicated by the technical defects of airships. The effectiveness of torpedoes discharged from airships is uncertain and generally distrusted. The accuracy with which a projectile can be discharged from a swaying balloon is limited by physical laws. Every boy knows how difficult it is to drop a stone from a height on a given point below, and the most carefully designed device for the discharge of torpedoes or other missiles from an airship will encounter the same difficulty. Hence the chief function of airships will be to convey pioneers with their tools and explosives quickly to the object which is to be destroyed, for the difficulty of landing will soon be overcome. In general, the airship will be able to approach with safety only at night, when it is not easy to steer correctly. Hence the superiority of the airship over the cavalry detachment, for these purposes, will reside chiefly in its ability to approach rapidly in an air line and to carry materials conveniently.

The airship will not soon exert any great influence on the tactical character of open campaigns, as its limitations prevent its taking any permanent place in the line of march. At present it is dependent on fixed inflating and landing stations of elaborate character. We may look forward to the invention of portable stations, which can be moved, at intervals, by means of automobiles or military railways. Two stations would be required, and they should be moved alternately, so that the radius of action of the airship shall extend from the advanced station to the enemy's lines, in one direction, and to the rear station, in the other direction.

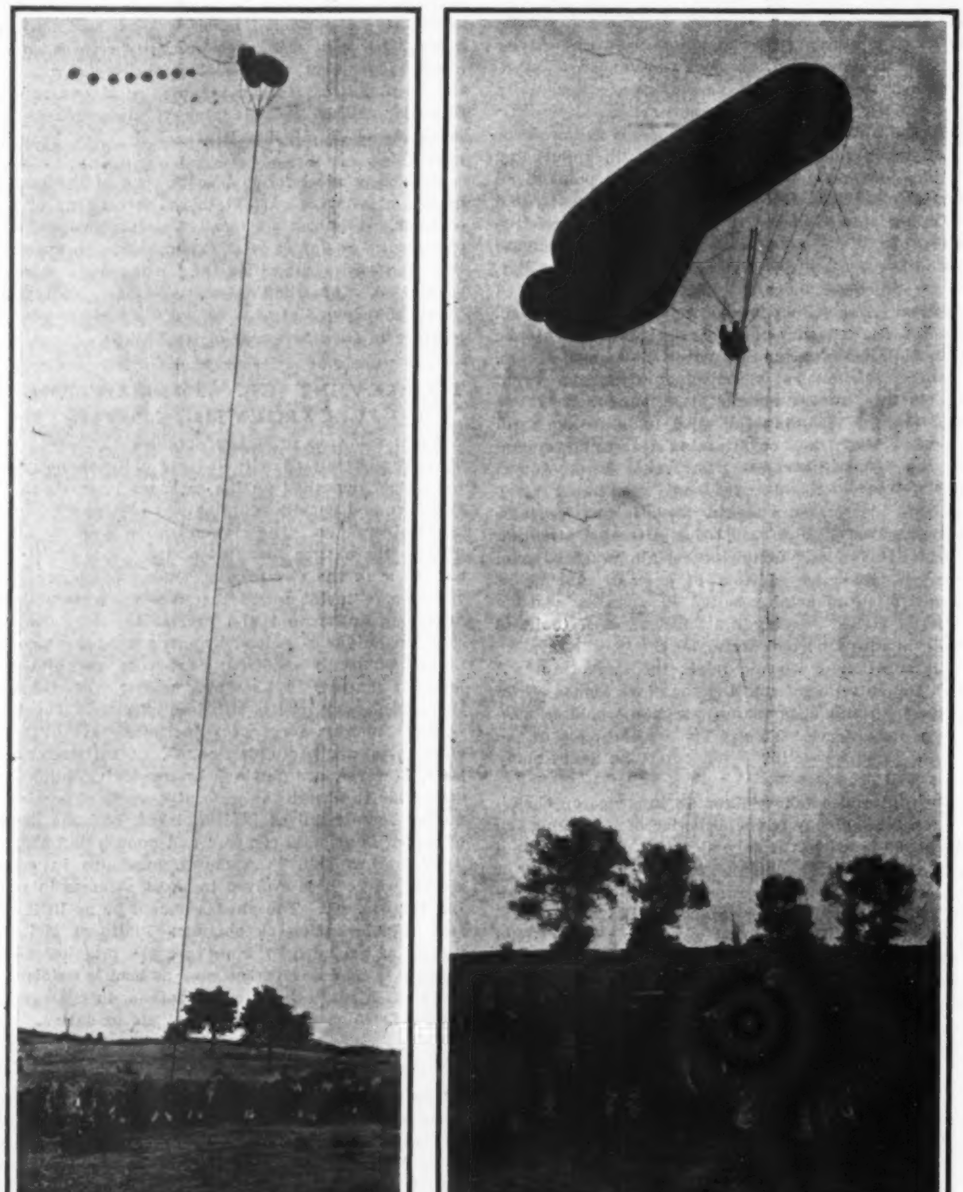
The extent to which it may become possible to employ airships in offensive warfare cannot yet be predicted. At present their usefulness in this field is limited by their small capacity for carrying guns and ammunition. Undoubtedly they will soon be improved in this respect, but the ballistic difficulty of firing almost vertically from great heights will still remain, and a descent to a lower level would bring the airship within the effective range of the enemy's fire. The invention of a nearly vertical machine gun revolving automatically about a vertical axis would furnish an effective defense against airships within an elevation of about 4,000 feet.

In France, according to report, objects arranged to represent the conditions of actual war have been hit and destroyed by heavy charges of explosives discharged from balloons. I do not know whether the shells were thrown by machine or by hand, or how well the hopes of the experimenters were realized. No official report has been published, but the results "are said to have been" surprisingly good. If this is true, the airship must have flown so low that in actual war it would have been exposed to the destructive fire of the enemy.

Tacticians have no especial reason to fear attacks by airships. A shell coming from above is no new thing in warfare. Heavy field howitzers project to a height of 10,000 feet shells which weigh 130 pounds, contain an explosive charge of 25 pounds and fall at angles of from 40 to 65 degrees with the horizon. It is doubtful whether any airship can carry many such shells, and the effect of its missiles will not be increased by the fact that they strike vertically. In favorable conditions the field howitzer works accurately and with a degree of security rarely found on the battlefield. The airship must go within the enemy's lines where it can find safety only at great heights, yet every additional yard of elevation diminishes the chance of dropping a shell upon a small object of attack.

Sieges offer more favorable conditions for the offensive use of airships on both sides. The objects of attack are larger and the tactical conditions more constant than in field warfare. Armed airships can also render good service in harassing and demoralizing a retreating enemy by direct attack, as well as in obstructing the retreat by destroying bridges and roads.

The airship should be able to communicate with headquarters by wireless telegraphy, in order to avoid the waste of time and energy involved in going back with information. On the other hand, tacticians will ask inventors for a portable device by which the wireless messages may be interrupted or made unintelligible.—Translated for the Scientific American Supplement from the Kriegstechnische Zeitschrift.



The Sphere. **TWO GERMAN WAR BALLOONS BEING OPERATED AT THE 1908 MANEUVERS.**

The activity of the German army and nation in the matter of navigable balloons is astonishing at the present time. They are entering into the struggle with the air with just the same enthusiasm that France evinced over the development of the submarine. The German Emperor recently inaugurated a balloon experiment house in which matter relating to ballooning is stored. In field work the cables of the German war balloons are worked by relays of soldiers, each squad working for a few minutes at winding the cable cylinder. If circumstances necessitate the rapid lowering of the balloon the cable is hauled down by men holding directly to it.

MILITARY TACTICS AND THE DIRIGIBLE AIRSHIP.

* This article is published in this issue because its conclusions are somewhat at variance with those arrived at by Mr. Hudson Maxim in his "Warfare of the Future," published on page 160. Both articles come from authentic sources and present the ideas of men who have made the science of warfare a special study.—Ed.

THE WARFARE OF THE FUTURE.*

THE PROBABLE DEVELOPMENT OF THE EXPLOSIVE AND THE PROJECTILE.

BY HUDSON MAXIM.

Concluded from Supplement No. 1731, page 159.

IN June, 1897, I delivered a lecture before the Royal United Service Institution of Great Britain, wherein I recommended a gun for throwing aerial torpedoes, that is to say, high explosive projectiles of large dimensions, which would be capable of penetrating the deck of any war vessel or of blowing up any war vessel when striking in the water beside it.

I proposed a gun of twenty-four-inch caliber, which need not necessarily be any heavier than the regular twelve-inch service rifle. I showed that this gun would be capable of throwing a projectile weighing a ton and a half and carrying half a ton of high explosive to a distance up to nine miles, according to the elevations. Our war department has now decided to build some guns of greatly increased caliber for the purpose of throwing heavier projectiles carrying much larger bursting charges of high explosive.

Although the initial velocity of these projectiles will not be as great as those now thrown from our high-power twelve-inch guns, still there will be far less relative energy lost during flight, and they will have proportionately far greater residual energy, so that the range will still not only be maintained but actually increased, although the trajectory will not be quite as flat as at present.

There is also another enormous advantage of this type of gun, and it is that the initial pressure need not be as great, so that a gun, instead of losing accuracy very rapidly after only the sixtieth round or so, will retain its accuracy up to several hundred rounds. These are some innovations in the right direction.

High explosives are destined to play a far more important part in future warfare than they have played in the past. There are three ways by which high explosives may be brought to bear upon the warships of an enemy for their destruction. One is in the bursting charge of the high explosive armor-piercing projectiles; another is in the submarine torpedo, either in the stationary submarine mine or the self-propelled torpedo, of which latter the Whitehead is the principal type; and the other is in aerial torpedoes, huge projectiles carrying charges of half a ton of high explosives dropped upon and about the warships of an enemy.

During the last decade the principal progress in the use of high explosives has been in the perfecting of bursting charges for armor-piercing projectiles; and to-day we are able to fire high explosive projectiles from power guns and to penetrate the thickest armor plate, without explosion until the projectile has passed through the plate, to be exploded behind the plate with a proper delay action fuse.

In the land battles of the future, lines of battle will circle sky line and opposing sky line, and over the stupendous arena missiles of death will shriek and roar, while sharpshooters with silent rifles will make ambush in every copse and hedge and highway. Aerial scouts will race across the sky, some in high flight and others hovering low.

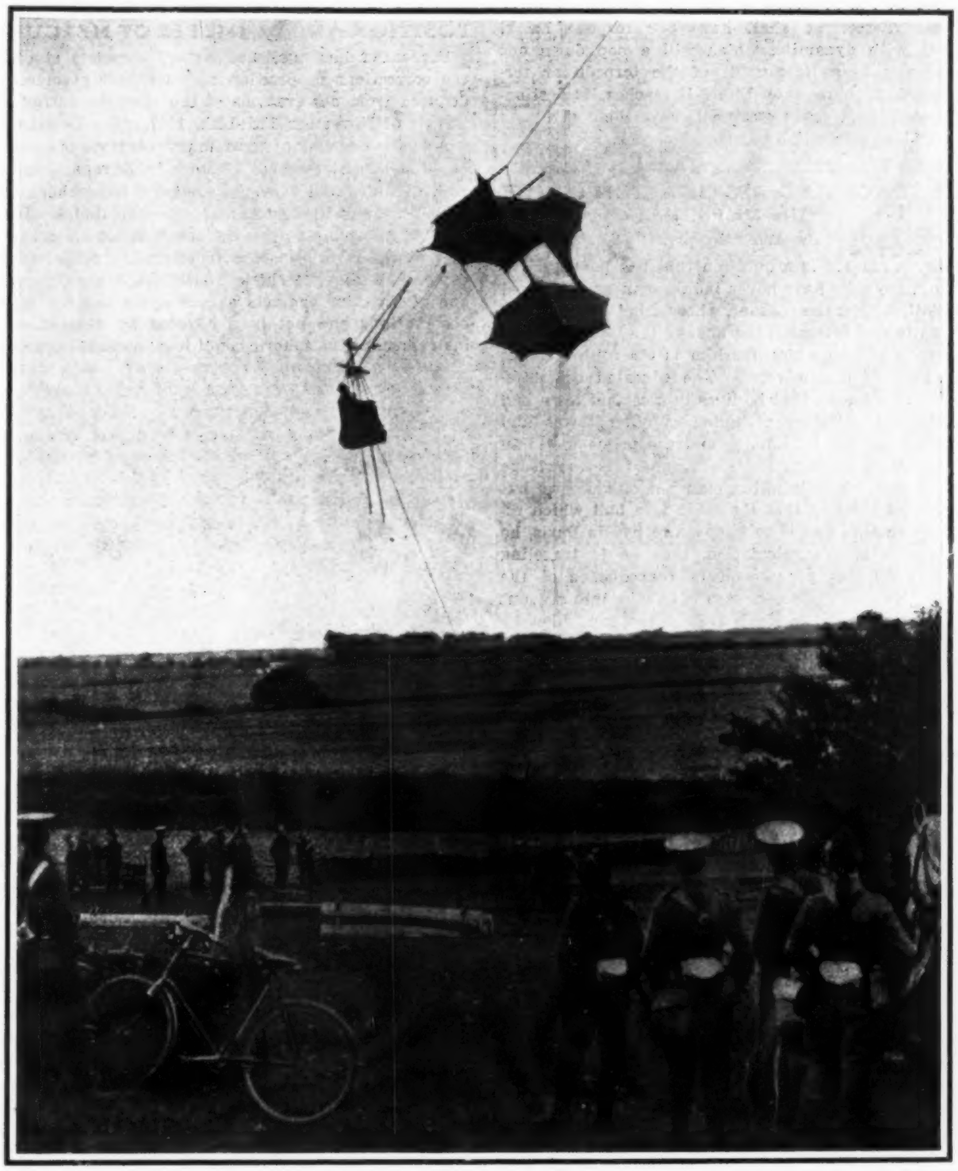
In this age of marvels with which the inventor is constantly surprising us, it does not do to sleep too late in the morning, else when we awake we may find ourselves laggards in the abject rear. Achievement now runs on so fast that it often outpaces the adjustment of our senses, and though we pinch ourselves to prove our wakefulness, still the sense of dreaming intrudes on consciousness and harasses conviction.

Many of us in still full life are able to go back far enough in yesterday to view the present through the wide eyes of wonder, while we are so fortified with expectation for the morrow that we look a second time to be assured whether or not that flock of clouds that skirts the sunset may be a fleet of airships climbing up the sky.

The flying machine is no longer confined to the realm of fancy or imagination, but the conquest of the air is already far advanced, and the era of practical utility is near. The wonder of yesterday becomes the commonplace of to-day, and the marvels of to-day will be commonplace to-morrow.

Now that the flying machine has become an actuality, and as all that now remains to be done is to perfect already existing means and apparatus in order to complete the conquest of the air, it is well for us to forecast some of the adjustments that will be necessary to meet the changed conditions when we shall have our aerial navies of commerce and of war.

That the flying machine will find very wide application in future warfare, there can be no doubt. Furthermore, it will be the demand for the flying machine as an engine of war that will give to the industry its greatest stimulus.



RECONNOITERING FROM A KITE IN THE RECENT BRITISH MANEUVERS.

MILITARY TACTICS AND THE DIRIGIBLE AIRSHIP.

Inventors will have to delve in the depths of their genius in order to develop, perfect, and bring the flying machine to the very high efficiency necessary to meet the requirements of government specifications.

There is no other incentive to invention so great as that which impels to the development and perfection of implements of war, for the very security of property, country, home, and life itself often depends upon a little lead over an enemy in war inventions.

Some terrible things have been predicted for the flying machine as a war engine. Many a sanguine inventor has claimed that with the advent of his flying machine, battleships, coast fortifications, and cities could be utterly destroyed by dropping dynamite from the air. It is comforting to know that no very great loss of life or property would result from dynamite dropped from flying machines, for the reason that dynamite requires confinement to work very wide destruction.

Dynamite must penetrate and explode inside battleships, earthworks and buildings in order to do very great damage. Half a ton of dynamite dropped upon the deck of a battleship might kill a few men, wreck some of the superstructure and dent the deck a bit, but the destruction would not be widespread and the crew below would be uninjured. Dropped on coast fortifications the damage would be negligible.

Half-ton bombs dropped into the streets of a large city, or on top of the great buildings, would shake a few foundations, break a lot of glass and kill a few people. The blast of the dynamite, not being confined, would rebound up into the air in the form of an inverted cone, and the effect in a horizontal plane would be small.

The flying machine will have very great use in war as a scouting craft for the purpose of locating an enemy and inspecting his position; but the enemy will have his aerial pickets out too, and there will be many a tilt in the air between the warring craft. Then it will be that speed will count for much and there will be intense rivalry between the nations in the production of flying machines that will fly fast and fly high, for those able to fly the highest will have a tremendous advantage over their enemies. It will be the high flyers who will win.*

I have noticed that great personal bravery is often a concomitant of great intellectuality, and it is proverbial that inventors are the dare-devilest men in the world; and when the flying machine inventor casts the earth loose and rounds the ecliptic with the Pleiades, leaves the earth road and cup-races with Jupiter on the cloud way, or goes tobogganing

* Address before the New York Section of the American Chemical Society.

* To be compared with the views of the author of the article on page 168.—ED.

down the sky slide, then the old soldier's oft-spun yarn of how his company mixed their bones with grape and canister becomes commonplace.

It will be great sport by and by to outrace and override the thunder storm, and there in the bright sunlight look down upon the rolling, seething mass of cloud spitting fire like an angry cat. We shall then seem to have nature at a disadvantage.

In the not distant future, we shall have our automobiles of the air, and in the wars of the future, we shall have our aerial battleships, our cruisers, our torpedo-boats and torpedo-boat destroyers. But they'll be airy, frail and fairy craft indeed compared with the grim steel monsters of the sea.

Although the value of the flying machine in future wars will be mainly as a scouting craft, still its value and importance for that service alone is hard to overestimate, for the flying machine vedettes will be at once the eyes and ears of the armies of the future; and they will have their use in naval warfare too, for there will be the aerial torpedo scout on the lookout for torpedoes and torpedo-boats, which will signal the approach of danger.

Possibly, too, we shall have our torpedo hawk, taloned with dynamite, which will swoop down out of the sky in swift pursuit of the torpedo or torpedo-boat and blow it up before it reaches its destination. But the torpedo craft will have their sky guns then and attack will be dangerous work.

OUR PLACE AND DESTINATION IN THE UNIVERSE.

By ABBÉ MOREUX.

"WHERE am I?" is a question that has presented itself to many who have never indulged in astronomical speculation. For the peasant, whose mind is as narrow as his life and interests, the answer is easy. He is in his native village which for him is the center, if not the whole, of the universe. The educated but unreflecting man knows that he lives in a certain town and country, the relations of which to other towns and countries and to the equator and the prime meridian are laid down on maps and globes, and this knowledge satisfies him. The thinking man not only knows but appreciates the fact that the earth is a ball which rotates on an axis and if he happens to live in Paris, he finds, by a simple calculation, that he is traveling nearly 1,000 feet per second in consequence of the earth's rotation. The next step is to take into account the revolution of the earth around the sun, whereby our philosopher finds that he is traveling at the rate of 1,600,000 miles per day, or 18.6 miles per second—that is to say, seventy times as fast as a cannon ball!

But this is a movement around the sun. Where is the sun? At one time the sun was regarded as the center of the universe, but now we know that this cannot be, for we have learned that the sun itself is moving with a velocity of about 10 miles per second or nearly a million miles per day.

The problem of the position of the solar system in the universe was first attacked, with some degree of success, by Sir William Herschel, whose conclusions were drawn from his study of the Milky Way. This white girdle of the celestial sphere is resolved by the telescope into a vast number of stars, of which more than 140 millions have already been counted on telescopic photographs of the heavens. Each of these stars is a sun like our own, probably surrounded by planets like the earth, and all these solar systems are moving, many of them more swiftly than ours.

How shall we find ourselves in this vast chaos? Here we see nebulæ which give us faithful pictures of past conditions of our own system. A misty, ill-defined central sun is surrounded by luminous spirals terminating in glowing globes, which are about to drop off and form planets. The beautiful nebula in Andromeda is of this character.

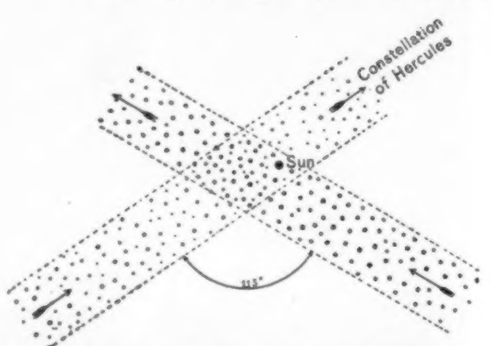
Again, there are vast masses of gas in which no law of formation can be discerned. Such is the great nebula in Orion. Other regions are so thickly studded with stars that the power of modern instruments is taxed to resolve and count them. Yet each of these stars is separated from its neighbors by distances which light, moving 186,000 miles per second, cannot traverse in less than three years, and some of the stars are so distant from us that light occupies several centuries in making the journey.

These numbers, which are not fantastic guesses, but the results of accurate measurement, may serve to give a faint idea of the immensity of the universe of which the earth and the sun and planets form so insignificant a part. Doubtless there are suns smaller than ours, but there are many which are thousands of times larger.

It was inferred from earlier measurements of stellar positions, distances and motions, that the solar system was situated comparatively near the center of a universe shaped like a thin double convex lens. This universe was supposed to rotate, as a unit, about its center, with the result that our sun (comparatively near that center but absolutely at an immense distance from it) moved in a circle of dimensions so vast that since the discovery of its motion it had not deviated appreciably from a straight line, but had steadily directed its course toward the constellation Hercules.

This simple scheme must now be abandoned, for it has been discovered that the visible universe consists of two distant parts. We are compelled to picture to ourselves two processions of stars moving in paths which make an angle of 115 degrees with each other. One of these stellar streams moves three times as fast as the other. Our sun forms a part of one of the streams and is at present at their intersection.

Hence we know, in a sense, where we are and the direction in which we are moving. But what is our goal, when shall we reach it, and what will happen then? Or shall we, in this crossing of the congested thoroughfares of the heavens, be shattered by a collision and resolved into a glowing nebula? This has been the fate of many stars, of several within the period of human history, and of one—Nova Persei—within a few years and under our very eyes.—L'Illustration.



OUR PLACE AND DESTINATION IN THE UNIVERSE.

POSITION AND DIAMETER OF MERCURY.

STROOBANT has published a very complete study of the corrections of position and diameter of Mercury, deduced from observations of the contacts during the transit of November 13th-14th, 1907. The Belgian astronomer collected a great many observations, made at 33 stations, of which 27 were in Europe, 4 in the United States and 2 in the southern hemisphere. To each observed time of contact was applied a correction which reduced it to the time at which the contact would have been observed from the center of the earth. All the geocentric times thus found for any one of the four contacts should agree exactly, if the observations had not been affected by differences in instruments, atmospheric conditions, personal equation, "black drop," etc. The first contact was usually noted incorrectly (too late) or missed altogether. In order to note a first contact correctly the observer must fix his attention on the point of contact in advance, and this cannot be done with perfect precision. Stroobant rejected a large proportion of the observations of the first contact for this reason, and some observations of other contacts for various other reasons. The observations retained included 9 of the first contact, 29 of the second, 68 of the third, and 57 of the fourth. The mean values for the first and second contacts gave the value 9.16 sec. for the angular diameter of Mercury, while the diameter deduced from the mean values for the third and fourth contacts is 9.10 sec. This second value is probably more accurate than the first, as it is based on a larger number of observations. Assuming 9.10 sec. as the angular diameter of Mercury on November 14th, 1907, its angular diameter at unit distance (the mean radius of the earth's orbit) is found to be 6.16 sec., instead of 6.61 sec., the value previously assumed. Hence the linear diameter, expressed as a fraction of the earth's becomes 0.350 instead of 0.373, the radius becomes 2,232 kilometers, and the volume, compared with that of the earth, becomes 0.042 instead of 0.052. The density of the planet is consequently 1.42 instead of 1.17, the value given in the tables.

Hydrosulphite, a bleaching substance, is produced by placing in a large tub of 500 quarts capacity, made of pine wood, 300 quarts of a solution of bi-sulphite of sodium, of 35 deg. to 40 deg. Bé, and then adding not exceeding one-fourth part of the total weight in bright zinc cuttings or zinc dust, until the surface is just covered. The zinc is gradually dissolved, during which time an increase in the temperature must be avoided by circulating cold water in earthenware pipes in the vessel. After about an hour the reaction ceases and the solution can be drawn off into a tub, which must be kept constantly full. After standing quiet for twelve hours, draw off the fluid standing over the sulphate of zinc-soda, the hydrosulphite, which can be used for the bleaching of woolens or silk fabrics.

Correspondence.

A MATHEMATICAL PROBLEM.

To the Editor of the SCIENTIFIC AMERICAN:

The writer has found a method of writing out (by addition and subtraction) powers of numbers in which the square is composed of two parts, the cube of three parts, the fourth power of four parts, and so on.

1^2	2^2	3^2	4^2	5^2	6^2	
(1)	(4)	(9)	16	25	36	..... (1)
(3)	(5)	7	9	11	13	..... (2)

In the above the squares of the first three (one more than the number of units in the index of the power) numbers are first found by any method after which the process may be continued as follows: $2^2 - 1^2 = 3$, which is written under 1, the square of 1. $3^2 - 2^2 = 5$, which is written under the square of 2. $5 - 3 = 2$, the common difference in line (2). The squares of succeeding numbers are then found by adding 7 to 9, which give 16, the square of 4, and 9 to 16, which gives 25, the square of 5, and 11 to 25, which gives 36, the square of 6, and so on.

1^3	2^3	3^3	4^3	5^3	6^3	
(1)	(8)	(27)	(64)	125	216	...... (3)
1	(7)	(19)	37	61	91	...... (4)
6	(12)	(18)	24	30	36	...... (5)

In the above the cubes of the first four numbers are first found by any method. Then $2^3 - 1^3 = 7$, which is written under 8, the cube of 2. $3^3 - 2^3 = 19$, which is written under 27, the cube of 3. And $19 - 7 = 12$, which is written under 7; and $64 - (27 + 19) = 18$, which is written under 19; and the common difference is found to be $18 - 12$, or 6, in line (5). Line (5) may be completed by subtracting 6 from (12) for the first column and adding 6 for each column to the right of (18). The first column is completed by subtracting 6, column (1), from (7) column (8) and writing the difference in line (4). $19 + 18 = 37$, which is written under 64, and the sum of the numbers under 4^3 is 125, the cube of 5. After the cube of any number is found the number immediately below it may be found by subtracting from that cube the preceding cube, or it may be obtained by adding the two numbers under the preceding cube. Thus, $125 - 64 = 61$, or $37 + 24 = 61$. The sum of the numbers under 5^3 $(125 + 61 + 30)$ is 216, the cube of 6. Each number in line (5) is six times the cube root of the corresponding numbers in line (3). The differences, line (4), are divisible by 6 with a remainder of 1. The difference between any two cubes is divisible by 6 with the same remainder as is obtained when the difference between the roots is divided by 6. Thus, $(12 - 3) \div 6 = 1$ with a remainder of 3, and $(12^3 - 3^3) \div 6 = 283$ with a remainder of 3.

Suppose it is desired to find the cubes of all the numbers from 994 to 1,000 inclusive. First find the cubes of 994 and of 995.

$995^3 =$	985,074,875	
$994^3 =$	982,107,784	
Difference =	2,967,091	................(6)
$6 \times 995 =$	5,970	................(7)
$995^3 =$	985,074,875	
$996^3 =$	988,047,936	
(6) + (7) =	2,973,061	................(8)
(7) + 6 =	5,976	................(9)
$997^3 =$	991,026,973	
(8) + (9) =	2,979,037	................(10)
(9) + 6 =	5,982	................(11)
$998^3 =$	994,011,992	
(10) + (11) =	2,985,019	................(12)
(11) + (6) =	5,988	................(13)
$999^3 =$	997,002,999	
(12) + (13) =	2,991,007	
(13) + 6 =	5,994	
$1{,}000^3 =$	1,000,000,000	

Since the cube of 1,000 is found to be correct it may be assumed that the numbers representing the other cubes are correct. It will be seen that the operation can be reversed.

In writing out powers higher than the third it is less laborious to perform as much of the operation as possible by subtraction instead of addition.

1^4	2^4	3^4	4^4	5^4	6^4	7^4	
(1)	(16)	(81)	(256)	(625)	1296	2401	...(1)
1	(15)	(65)	(175)	(369)	671	1105	...(2)
2	14	(50)	(110)	(194)	302	434	...(3)
12	36	(60)	(84)	108	132	156	...(4)

In the above the fourth power of the first five numbers is found by any other method after which the remaining numbers inclosed in parentheses are found as follows: $16 - 1 = 15$, $81 - 16 = 65$, $256 - 81 = 175$, $625 - 256 = 369$, $65 - 15 = 50$, $175 - 65 = 110$, $369 - 175 = 194$, $110 - 50 = 60$, which is written under 50, and $194 - 110 = 84$, which is written under 110, and $84 - 60 = 24$, the common difference in line

(4). The columns under 1^4 and 2^4 are filled out to show that the method as previously explained holds true here as well as with the cubes of numbers. This is also true of other powers.

The sum of the numbers in any column is equal to the required power of the next higher number. In any column the sum of the numbers in lines (2), (3), and (4) is the number in line (2) in the next column, and the sum of the numbers in lines (3) and (4) is the number in line (3) in the next column. In all cases in any column the sum of the numbers in the last two lines is the number in the next column in the line before the last. $2 + 12 = 14$, $14 + 36 = 50$, $50 + 60 = 110$, and so on.

In any column a number subtracted from the corresponding number in the next column gives the number beneath the corresponding number except in regard to the last two lines. Thus, under 6^4, $671 - 369 = 302$, but $302 - 194 = 108$, which is written under 194.

The principles herein mentioned hold true in writing out other powers as well.

In writing powers by this method the common difference in the last line is, for the

square	2	(1)
cube	6	$(2) = 3 \times (1)$
fourth power	24	$(3) = 4 \times (2)$
fifth power	120	$(4) = 5 \times (3)$
sixth power	720	$(5) = 6 \times (4)$
seventh power	5,040	$(6) = 7 \times (5)$
eighth power	40,320	$(7) = 8 \times (6)$
ninth power	362,880	$(8) = 9 \times (7)$
tenth power	3,628,800	$(9) = 10 \times (8)$

The numbers under 1^5 are:

1
1
0
30
0

the sum being 32, the fifth power of 2, and negative numbers first appear under 1^6, the numbers being:

1
1
2
—60
480
—360

the sum of which is 64, the sixth power of 2.

The numbers under 1^{10} are:

1
172,105
—1,286,102
4,215,980
—7,868,540
8,566,440
—2,719,660
—8,749,400
16,634,700
8,964,500

the sum being 1,024, the tenth power of 2.

No doubt further investigation would reveal other interesting features. RICHARD A. BELL.

Lakewood, Ohio, February 1, 1909.

THE CAUSE OF EARTHQUAKES.

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

The tragedy of Messina has brought forth many theories as to the cause of earthquakes. Most of these theories doubtless are mere guesses, to which their promulgators endeavor to reconcile the facts; but some, on the other hand, are results of scientific investigation and deduction.

Half as a guess and half as a deduction, I offer the following theory; which, so far as I know, has never before been advanced:

It is commonly accepted as a fact that the attraction of heavenly bodies—chiefly the sun and moon—acting in conjunction with the centrifugal force of the earth, causes the movement of the tides. Now, this pulling strain is exerted equally upon land and sea; but the land, being rigid, does not yield to the force as does the sea.

This process may continue for ages without visible effect. Yet the earth's structure feels the repeated strain, and some day yields; then there is an earthquake. This shaking down seems to solidify the earth in that vicinity, perhaps by filling up cavities caused by percolation of water. Beyond occasional subsiding tremors, it is quiet until its structure again becomes weakened to the breaking point.

The center of disturbance is generally at or near the coast; the edge of the continent or island crumbles more easily than its interior. Several reasons for this fact may be advanced. The edge of a continent or island is less firmly braced than its interior; the undermining effects of water are perhaps greater; and twice each day the shore is subjected to the shifting strain of enormous weights of water. The tides are like a gigantic hammer, pounding ceaselessly and irresistibly.

At times, two or more causal forces acting together operate to produce abnormally high tides. At such times the strain on the land is proportionately greater, and earthquakes are most liable to occur.

There may be also some significance in the fact that most of the great earthquakes of record have had their centers in points on or near the fortieth parallel of north latitude. Peking, China; the islands of Japan; San Francisco, Cal.; the Missouri "sunk lands"; Charleston, S. C.; Lisbon, Portugal; Messina, Sicily—they form a belt around the world. Seismic disturbances occurring in other zones can generally be traced to purely local volcanic action.

Taking all these facts into consideration, it may be inferred that the following places are most liable to a shaking up, especially in times of flood tide: Lisbon, Portugal (after long immunity); Gibraltar, Valencia, and other places on the Spanish coast; the Balearic Islands; Tangier, Tripoli, Alexandria and Cairo, in Africa; Rome and Naples, Italy; the island of Sardinia; Palermo and Trapani, Sicily; the Grecian Archipelago; Constantinople, Turkey; Peking, Tien Tsin, Taku, Port Arthur, China; Seoul, Korea; Nugata, Akita, Matsumai, Hakodate, Sendai, Tokio, Yokohama, Japan; Sacramento and Eureka, Cal. (San Francisco presumably "settled"); New York, Philadelphia, Washington, Baltimore, Richmond; and, above all, the Azores Islands. To a lesser degree, owing to their inland location, the following American cities also are liable: Salt Lake City, Denver, Kansas City, Indianapolis, Cincinnati, Pittsburg.

No doubt, as many earthquakes occur south of the equator as north of it, but for several reasons less is heard of them. In the first place, the southern hemisphere consists mainly of water. Shocks innumerable may rend the ocean's bed with little or no loss of human life. Then too southern lands are, as a rule, less thickly populated than those of the North Temperate Zone. There are fewer large cities with massive buildings to fall down and crush out lives. There are but scant means for reporting disasters that do occur in uncivilized or semi-civilized countries.

However, there are several considerable cities within the putative danger zone. If the fortieth parallel of southern latitude is as vicious as its northern counterpart, we may some day see in Wellington, New Zealand, for instance, a second Messina.

WALTER E. KEEVER.

Detroit, Mich., February 5, 1909.

THE PASSING OF THE WHALE.

To the Editor of the SCIENTIFIC AMERICAN:

In the SCIENTIFIC AMERICAN SUPPLEMENT for November 28 appears an article, "The Passing of the Whale," written by Mr. Frederic A. Lucas of the Brooklyn Institute.

The title of this article may perhaps very appropriately characterize the present situation concerning the bowhead or Greenland whale, but as regards the whales of the genus Balænophora and the humpback whale, the author is not altogether correct.

For an American, who sees a once flourishing industry nearing extinction, it is perhaps only natural to take a gloomy aspect of the situation. When I visited Newfoundland during the spring months last year, I was generally met with: "Don't talk whaling; we are sick of it." Mr. Lucas makes the Newfoundland case a prominent part of his argumentation.

In the absence of more definite investigations as to the real cause of the rapid diminution of whales along the coast of Newfoundland, it may be conjectured that this case most likely may be ascribed to the biological condition in the Labrador current.

I know of only one instance of a similar case, and that is the fate of the two whaling stations which in the eighties were started by the Russians on the Murman coast. After some seasons of successful hunting the whale became scarcer and scarcer, until the work had to be stopped entirely.

Not so very far therefrom is the Finmarken coast of Norway. Here whaling was commenced as early as 1868—forty years ago—and this stretch of coast was scoured by about thirty whaling steamers, more or less, until the year 1904, when the agitation of the fishermen caused the Norwegian Storthing to interfere.

The question then naturally arises: Are localities swept by a cold polar current during the spring months, in which the migration of whales from southern waters takes place, fit for production of that sort of plankton which forms the bulk of the food for the whales in question?

It may be taken as granted that the main body of the whales, which during the early spring months migrate northward through the Atlantic, take an easterly direction and spread fanlike up toward Iceland, the Faeroe Islands, Shetland, Spitzbergen, and the northern coast of Norway. Now the question is: Does the western part of the Atlantic, bordering upon Nova Scotia, Cape Breton, and Newfoundland, offer them any temptation in the form of sufficient food, which they may be supposed to find at that time of the year in abundance in and along the borders of the Gulf Stream?

I think the question concerning Newfoundland and the Murman coast may be summed up thus: A limited number of whales migrate every spring or summer up to these localities; and so long as they are left undisturbed, stay, and return in slowly increasing numbers. So long as the hunting of these whales is not excessive, the supply may cover the catch, differently if otherwise.

One thing is certain: Some whalers, who operate in the sea between Spitzbergen and Norway, use their thermometers at intervals; and if the temperature of the water sinks below a certain point, they steam away until they find conditions which, according to their experience, are fit for the whales to find their food in. Those met with in the cold areas are runners, which are very difficult to hunt, being too restless.

Then in the Labrador current and also along the Murman coast are vast quantities of ice melting, causing the contents of salt in these waters to sink more or less below the normal. That such condition materially affects various forms of plankton life is proved beyond question.

Turning then to other whaling grounds, there are the whales along Iceland and the Faeroes and that part of the Atlantic lying northeasterly of these islands. These localities have been hunted for nearly twenty years by a large number of steamers and sailing vessels for plankton whales and bottlenose whales. The whaling from Ireland, the Hebrides, and the Shetland Islands is of a more recent origin, but these localities lie right in the track of the migration of the North Atlantic whales. The statistics of the catch from all these localities are easily available.

But important as they are, the whaling grounds of the North Atlantic cannot compare with those of the southern hemisphere, south of the fortieth parallel, practically untouched.

I may quote a remark by an American captain, related in the Fishing Gazette for August 15: "Capt. Strumme, of the Lunenburg (U. S.) barkentine 'Stranger,' has reached New York after a trip to South Georgia Island with supplies for the whaling station there. According to the captain, it is nothing but whales in those waters. There are narwhals or unicorn whales and humpbacks; and while the 'Stranger' lay in bay one blue whale was taken that measured ninety-five feet. The oil is sent to Buenos Ayres, whence it is transshipped to Europe and to some extent to New Bedford," etc.

But I think the best proof of the correctness of this statement may be deduced from the fact that from a comparatively poor country like Norway, where capital does not grow on trees, during these last three years expeditions have been fitted out for those waters, representing several millions of kroners. And before our people invest such sums they are tolerably certain that this saving is for to-morrow.

The number of whales in this vast expanse of waters may with tolerable certainty be counted by hundreds of thousands. The bulk of the whales caught around South Georgia, the only locality from which there is any degree of experience at present gathered, are the humpbacks. The female of this species is supposed to go pregnant in from ten to twelve months; and judging from the large number of fetuses found in humpback females killed on the coast of Feismarken at different times of the year, they must be one of the most prolific of whales. Anybody can then figure out for himself if there is at present very much need of restrictive measures, least of all of an international character.

Truly, if it should happen that, as in the seventeenth and eighteenth centuries, most seafaring nations should make a rush, eager to secure their part of the spoil, there might be a serious depletion. But nowadays, with the limited use for the principal product, the oil, no such emergency may be feared.

The bowhead is in quite another and serious situation at present. When the lucky catch of a few specimens of a whale may cover the venture, the inborn inclination of man to gamble may tempt him to play in the lottery until he eventually realizes that all the prizes have come out. Then again it is hard to break an old practice, handed down through generations.

But it would be more than a pity if the few straggling representatives left of a creature which has given to mankind untold fortunes, should succumb to the greed of man, to be offered upon the altar of vanity. J. A. MÖRCH.

Christiania, Norway, December 16, 1908.

Cement for High Temperatures.—2 parts of borax, 10 parts of oxide of zinc and 21 parts of pulverized manganese, are stirred with water glass solution into a dough-like mass and used at once. The cement dries slowly, but is capable then of withstanding a fairly high temperature.

WIRELESS TELEPHONY.*

ITS HISTORY AND PRESENT STATUS.

BY REGINALD FESSENDEN.

FOR wireless telephony three things are necessary:

1. Means for radiating a stream of electrical waves sufficiently continuous to transmit the upper harmonics on which the quality of the talking depends.

2. Means for modulating this stream of waves in accordance with the sound waves.

3. A continuously responsive receiver giving indications proportional to the energy received, and capable of responding with sufficient rapidity to the speech harmonics.

Work on the wireless telephone was commenced before a satisfactory means was discovered for producing sustained oscillations.

To ascertain the number of sparks per second which was necessary to determine articulate speech, a phonograph cylinder was taken and grooves were cut in it

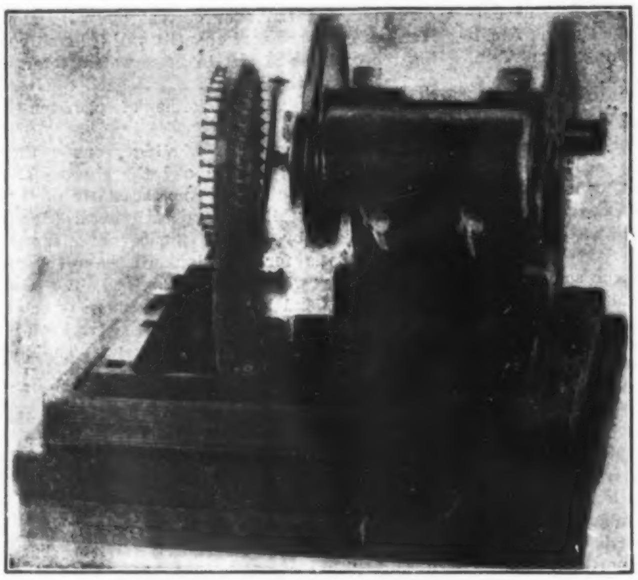


FIG. 1.—ROTATING SPARK GAP.

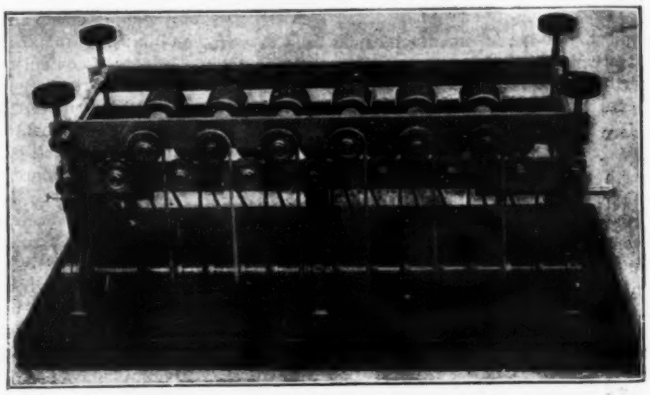


FIG. 4.—MULTIPLE GAP WITH ROTATING ELECTRODES.

FIG. 2.—APPARATUS FOR OPERATING THE ARC IN A GAS UNDER PRESSURE.

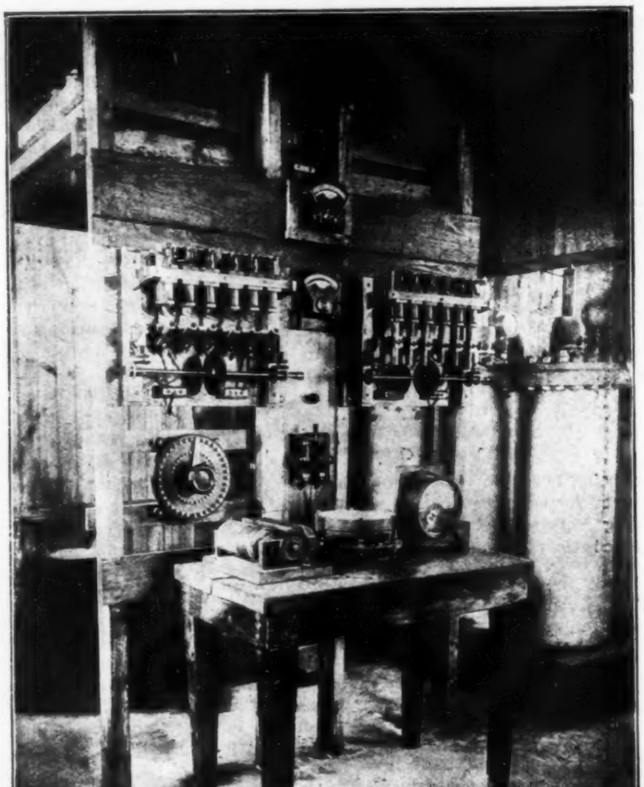


FIG. 5.—MULTIPLE ARC GAP WITH ELECTRODES OF DIFFERENT MATERIALS.

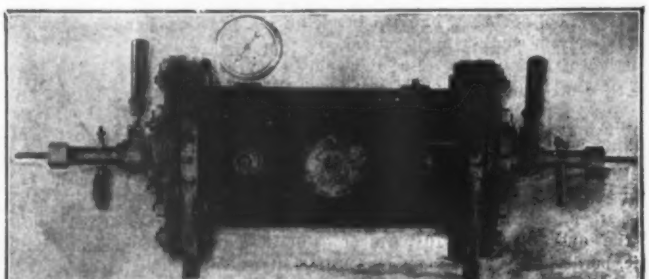


FIG. 3.—APPARATUS FOR OPERATING THE ARC IN A GAS UNDER PRESSURE.

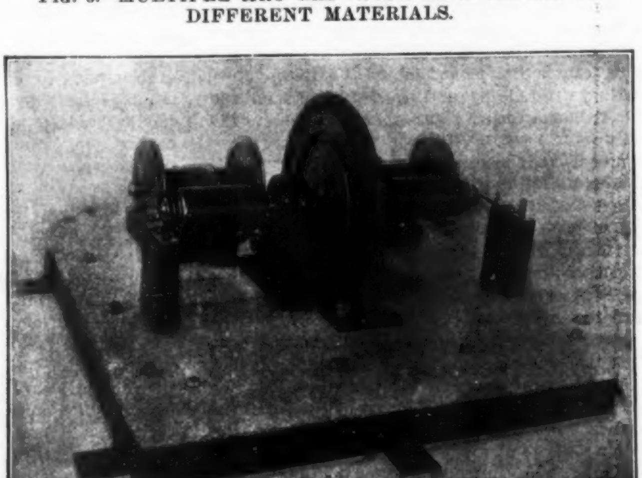


FIG. 6.—CONDENSER DYNAMO.

longitudinally. It was found in this way that practical transmission could be accomplished with 10,000 breaks per second. It is believed now that this number is unnecessarily high, possibly owing to the fact that it was impossible to cut the grooves on the cylinder without producing ridges.

The lower limit may be fixed in another way. Electrical circuits met with in actual working have resistance, self-inductance capacity, and leakance. Heaviside gave the differential equations for the pressure and current over such circuits when alternating voltages were applied, but no method of solution being known the mathematical treatment of such circuits was restricted to cases where one of the constants was neglected, until Dr. A. E. Kennelly in a masterly series of papers gave the complete solution.

The results were immediately found applicable to a great variety of problems, such as the transmission of signals through cables and of telephonic speech through various types of circuits.

In this way Dr. Kennelly* by comparing the results obtained by Dr. Hammond V. Hayes† in practical telephonic transmission over loaded lines with the theoretical values of the current for different harmonics showed that harmonics above 2,000 per second could be neglected for telephonic transmission.

The writer has never succeeded in obtaining good talking with such a low frequency, but under favorable conditions fairly satisfactory speech may be obtained with 5,000 interruptions per second. For really good transmission, however, the radiation must be practically continuous, for if the spark frequency is less than 20,000 per second there is a disagreeable high pitch note in the telephone, not noticeable perhaps at first but apt to become annoying with use. The most satisfactory way is, of course, to use a source of sustained oscillations.

It fortunately happens that for wireless telephonic purposes it is inadvisable to use a wave frequency of less than 25,000 per second, on account of the difficulty in radiating energy with low frequencies.

The receiver must, of course, be continuously responsive. If, for example, it had to be tapped back

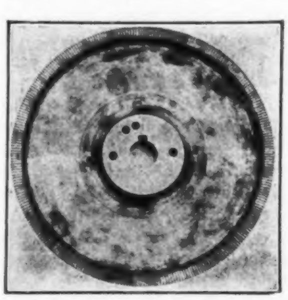


FIG. 8.—A FIELD DISK.

in order to restore it to the responsive condition, speech could not be transmitted.

It must also give indications proportional to the energy received or the character of the speech will be distorted.

It must also respond with sufficient rapidity. If, for example, it takes a thousandth of a second to restore itself to its original resistance the receiver will obviously not record the higher harmonics. I have experimentally determined that a receiver which restores itself in the ten-thousandth part of a second acts with sufficient rapidity.

* Kennelly, "Distribution of Pressure and Current over Alternating Current Circuits," Harvard Engineering Journal, 1906, page 43.

† Hayes, "Loaded Telephone Lines in Practice," Transactions International Electrical Congress, St. Louis, vol. iii.

The writer has been asked on several occasions how the wireless telephone came to be invented. In November, 1899, shortly prior to the delivery of my previous paper,* while experimenting with a receiver shown in that paper, I made some experiments with a Wehnelt interrupter for operating the induction coil used for sending.

In the receiver mentioned the ring of a short-period Elihu Thomson oscillating current galvanometer rests on three supports, i. e., two pivots and a carbon block, and a telephone receiver is in circuit with the carbon block. A storage battery being used in the receiver circuit† it was noticed that when the sending key was kept down at the sending station for a long dash the peculiar wailing sound of the Wehnelt interrupter was reproduced with absolute fidelity in the receiving telephone. It at once suggested itself that by using a source with a frequency above audibility wireless telephony could be accomplished.

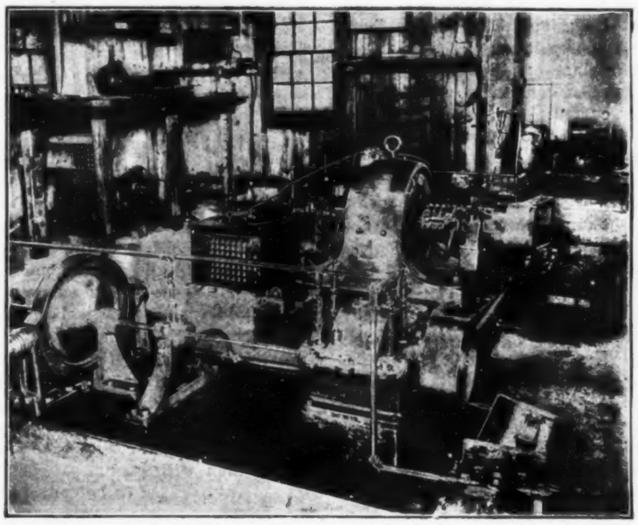


FIG. 7.—A TYPE OF HIGH FREQUENCY ALTERNATOR.

Prof. Kintner, who was at that time assisting me in these experiments and to whose aid their success is very largely due, was kind enough to make the drawings for an interrupter to give 10,000 breaks per second. Mr. Brashear, the celebrated optician, kindly consented to make up the apparatus and it was completed in January or February, 1900.

The experimental work was, however, delayed, as the writer was at that time transferring his laboratory from Allegheny, Pa., to Rock Point, Md., and it was not until six months later that the stations at that point were completed and a suitable mast was erected for trying the apparatus.

The first experiments were made in the fall of 1900 with the above mentioned apparatus which was supposed to give 10,000 sparks per second but which probably gave less. Transmission over a distance of one mile was attained but the character of the speech was not good and it was accompanied by an extremely loud and disagreeable noise, due to the irregularity of the spark.

* Transactions American Institute Electrical Engineers, November 22, 1899.

† U. S. patent, 706,736, December 15, 1899.

By the end of 1903 fairly satisfactory speech had been obtained by the arc method above referred to, but it was still accompanied by a disagreeable hissing

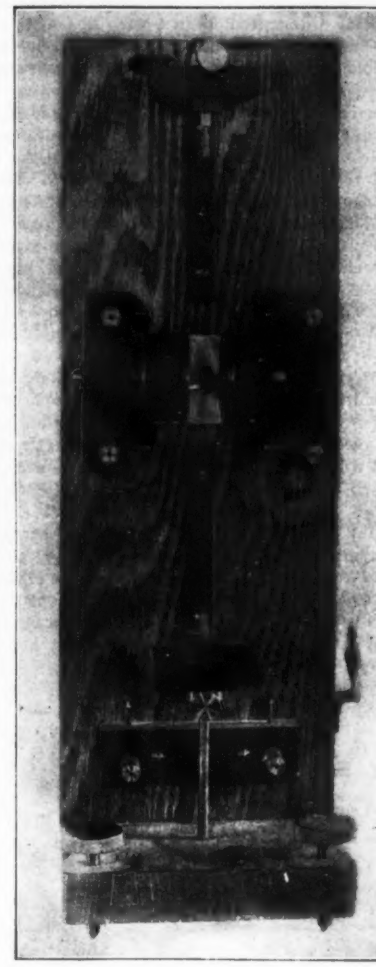


FIG. 10.—HIGH FREQUENCY ALTERNATOR FOR USE ON SHIPBOARD.

noise. In 1904 and 1905 both the arc method and another method in which the 10,000 cycle alternator above referred to was employed, had been developed to such an extent that the apparatus could be used practically and sets were advertised and tendered to the United States government. The transmission was, however, still not absolutely perfect.

FIG. 9.—ARMATURE AND FIELD COILS.

By the fall of 1906 the high frequency alternator had been brought to a practical shape and was used for telephoning from Brant Rock to Plymouth, a distance of 11 miles, and to a small fishing schooner, this being the first instance in which wireless telephony was put in practical use. The transmission was perfect and was admitted by telephone experts to be more distinct than that over wire lines, the sound of

breathing and the slightest inflections of the voice being reproduced with the utmost fidelity.

As it was realized that the use of the wireless telephone would be seriously curtailed unless it could be operated in conjunction with wire lines, telephone relays were invented both for the receiving and transmitting ends and were found to operate satisfactorily, speech being transmitted over a wire line to the station at Brant Rock, retransmitted there wirelessly by a telephone relay, received wirelessly at Plymouth and there relayed out again on another wire line. On December 11th, 1906, invitations were issued to a number of scientific men to witness the operation of the wireless transmission in conjunction with the wire lines. A report of these tests appeared in the American Telephone Journal of January 26th and February 2nd, 1907, the editor being one of the men present.

In July, 1907, the range was considerably extended and speech was successfully transmitted between Brant Rock and Jamaica, Long Island, a distance of nearly 200 miles, in daylight and mostly over land, the mast at Jamaica being approximately 180 feet high.

In 1907 several European experimenters succeeded in transmitting speech wirelessly, using some of the earlier forms of the writer's arc method, and some months ago the vessels of our Pacific squadron were equipped with wireless telephones, using this arc method, by another American company.

1. *Methods and Apparatus for Producing the Electromagnetic Waves.*—Fig. 1 shows a rotating spark-gap giving approximately 20,000 discharges per second. This was connected to a 5,000-volt source of direct current. The terminals are of 40 per cent platinum-iridium. In operation the apparatus is arranged to charge a condenser to a definite potential and discharge it.

Figs. 2 and 3 show forms of apparatus for operating the arc in a gas under pressure.

The apparatus of Fig. 3 is also used for the arc in vacuum and the critical distance arc.

Fig. 4 shows a multiple gap with rotating electrodes, brass, amalgamated zinc, and graphite being used.

Fig. 5 shows a multiple arc gap with electrodes of different materials, the upper terminals being water-cooled.

Fig. 6 shows a condenser dynamo.

Fig. 7 shows a general view of one type of high-frequency alternator. It is driven by a motor and a DeLaval gear. It has been operated at 96,000 cycles per second, but is generally run at 81,700.

Fig. 8 shows a field disk; it is 12 inches in diameter and there are 300 slots on it.

Fig. 9 shows the armature and field coils. There are 600 armature slots each containing two turns of 13 mil wire. The field current is 5 amperes. The resistance of the armature is 6 ohms; it gives 160 volts and about 7 or 8 amperes. Other armatures have been constructed having a resistance of 4 ohms. For some work double armatures are used giving about 270 volts. The output of the single armature machines at 81,700 cycles is approximately 1 kilowatt. The output of the double armature machine is approximately 2 kilowatts.

Other types of high frequency alternators are under construction. One type shown in Fig. 10 is designed for use on shipboard. The armature disk is 6 inches in diameter and two armatures are used. It is arranged to be mounted on gimbals and to be driven by a steam turbine connected to the steam pipe by flexible armored steam hose. The frequency is about 100,000 and the output about 3 kilowatts.

Another type, which is at present being constructed by Mr. Alexanderson, to whose efforts the success of this type of generator is largely due, is designed to have an output of 10 kilowatts. Designs have been made for a generator of still larger size with a calculated output of 50 kilowatts and a frequency of 50,000. This machine is intended for transatlantic work.

For some of these machines, instead of driving by gear or steam turbine, a special two-cycle motor has been devised, to operate at a frequency of 500 cycles per second.

The high frequency alternator method is believed to possess a number of advantages over other methods, inasmuch as it is set in operation by merely opening a steam valve and has no complicated electrical apparatus or circuits of any kind. The speed is regulated by the steam pressure, this being accomplished by an electrically operated reducing valve.

For measuring the frequency various speed indicators have been tried, but it has been found that the best way is to use a resonant circuit with an ammeter shown in Fig. 9 in it,* this being an extremely sensitive means of indicating the frequency and in addition affording a means of automatically keeping the speed constant to a small fraction of a per cent. The reducing valve is adjusted so that if left to itself the machine will run slightly above speed. As soon as it reaches one-tenth of one per cent higher than its designed speed the resonance begins to fall and a contact is opened which slightly throttles the steam. In this way the frequency is kept varying between the limits of one-tenth of one per cent above speed and one-tenth of one per cent below speed. Where the drive is electric instead of by turbine, a storage battery is used to drive the two-phase generator and even better results may be obtained as regards regulation than with steam.

(To be continued.)

* Electrical World and Engineer, November 11, 1899.

EARTHQUAKE FORECASTS.—III.*

FUTURE POSSIBILITIES.

BY G. K. GILBERT.

Concluded from Supplement No. 1731, page 155.

MORAL.

It remains to draw the moral. In view of these facts as to forecasting, and of the further fact that we have in our land a district subject to strong earthquakes, there are duties to be recognized and policies to be advocated. It is the duty of investigators—of seismologists, geologists, and scientific engineers—to develop the theory of local danger spots, to discover the foci of recurrent shocks, to develop the theory of earthquake-proof construction. It is the duty of engineers and architects so to adjust construction to the character of the ground that safety shall be secured. It should be the policy of communities in the earthquake district to recognize the danger and make provision against it.

The general fact of local danger spots, where the agitation during strong earthquakes is peculiarly violent, has long been familiar. It is known that they are commonly found in lowlands where the underlying formation is a deep deposit of alluvium or other unconsolidated material, and that such material, while it aggravates great shocks, absorbs and quenches small ones. It is also known that the local phenomena are in some way connected with the transformation of earthquake waves in passing from elastic to inelastic material. But a mechanical theory of the phenomena is yet to be supplied. For economic, as well as scientific purposes, this is one of the important fields for investigation. In Japan, where earthquakes are much more frequent than in any portion of our own land, the subject has been studied and may still advantageously be studied, by the observation of natural shocks. In America the problem can be more readily studied by means of artificial earthquakes in the laboratory, continuing the line of experimentation begun by Rogers.† When the underlying principles have become known, it will be comparatively easy for geologists, engineers, and architects to estimate the danger factor in places to be occupied by buildings.

The San Andreas rift,‡ now traced through so much of its length as traverses inhabited areas, is recognized as a danger belt of a peculiar character, to be avoided especially by water conduits and railways. Although it is probably the most extensive rift belt in the country, it is not the only one, and the positions of all others should be determined and mapped. The foci or epicenters of recurrent earthquakes are also localities of special danger, even though the underlying formation is firm and elastic. So far as the earthquake faults reach the surface of the ground, the epicentral tracts coincide with the rift belts and fault scarps; but some of the foci are doubtless wholly subterranean and need for their discovery a seismic survey like those conducted in Japan, Italy, England, and, since the Valparaiso earthquake, in Chili. In Japan, which now takes first place in the study of earthquakes, the survey is conducted by a system of seismographic observatories in co-operation with a large body of local correspondents—a mode of organization quite analogous to that of our Weather Bureau, with its system of thoroughly equipped stations and its widespread corps of volunteer observers.

Much progress has already been made in determining the principles of earthquake-proof construction. After each great earthquake which in modern times has devastated a city, there has been engineering study of the buildings which successfully resisted the vibrations and of those which succumbed, so that the construction of the future might profit by the experience of the past. In various countries, and especially in Japan, there have been series of experiments either for determining the mechanical character of earthquake shocks, or for testing the ability of different types of construction to withstand them. The results of these observations and experiments have helped to determine the building regulations and building methods in various earthquake districts. For our own purposes there are needed, not merely a complication of the principles developed elsewhere and of the deductions from recent experience in California, but special lines of investigation, covering theoretically and experimentally the materials and architectural methods employed in this country at the present time.

In the line of experiment, we may well follow the example of our oriental neighbors, by constructing a machine which will give to a platform all the motions characteristic of a violent earthquake, and using the platform as a testing ground for types and materials of construction.

The proposition that it should be the policy of the inhabitants of an earthquake district to recognize the danger and make provision for it appears self-evident, but I regret to say that its soundness is not universally recognized in California. As long ago as 1868, Whitney, speaking of the Pacific States, said:

"The prevailing tone in that region, at present, is that of assumed indifference to the dangers of earthquake calamities—the author of a voluminous work on California, recently published in San Francisco, even going so far as to speak of earthquakes as 'harmless disturbances.' But earthquakes are not to be bluffed off. They will come, and will do a great deal of damage. The question is, How far can science mitigate the attendant evils, and thus do something toward giving that feeling of security which is necessary for the full development of that part of the country?"*

This policy of assumed indifference, which is probably not shared by any other earthquake district in the world, has continued to the present time and is accompanied by a policy of concealment. It is feared that if the ground of California has a reputation for instability, the flow of immigration will be checked, capital will go elsewhere, and business activity will be impaired. Under the influence of this fear, a scientific report on the earthquake of 1868 was suppressed.† When the organization of the Seismological Society was under consideration, there were business men who discouraged the idea, because it would give undesirable publicity to the subject of earthquakes. Pains are taken to speak of the disaster of 1906 as a conflagration, and so far as possible the fact is ignored that the conflagration was caused, and its extinguishment prevented, by injuries due to the earthquake. During the period of after-shocks, it was the common practice of the San Francisco dailies to publish telegraphic accounts of small tremors perceived in the eastern part of the United States, but omit mention of stronger shocks in the city itself; and I was soberly informed by a resident of the city that the greater number of shocks at that time were occasioned by explosions of dynamite in the neighborhood. The desire to ignore the earthquake danger has not altogether prevented the legitimate influence of the catastrophe on building regulations and building practices, but there can be little question that it has encouraged

* Abstracted from Presidential address to the American Association of Geographers.

† Prof. F. J. Rogers, of Stanford University, gave harmonic motion in a horizontal direction to a box of sand, and found that under certain conditions a body resting on the sand received motion which was not harmonic, and which had greater amplitude and a much greater maximum acceleration than the motion of the box. His experiments are described in the "Report of the California Earthquake Commission," Vol. I., Part II., pp. 326-35.

‡ "The California Earthquake Investigation Commission," Vol. I., Part II., pp. 25-53.

* "Earthquakes," by J. D. Whitney, North American Review for April, 1869, Vol. CVIII, p. 608.

† "California State Earthquake Investigation Commission," Vol. I, Part II, p. 434.

unwise construction, not only in San Francisco but in other parts of the malloseismic district.

The policy of concealment is vain, because it does not conceal. It reflects a standard of commercial morality which is being rapidly superseded, for the successful salesman to-day is he who represents his goods fairly and frankly. It is unprofitable, because it interferes with measures of protection against a danger which is real and important.

To understand the practical importance of the earthquake danger, let us for a moment consider it from the insurance point of view. To determine rate of premium, an insurance company first computes the risk, and this computation is based on past experience, comparing the actual losses with the amount exposed to loss. We know, with fair approximation, the loss of life by earthquake in California from the year 1800, and can compare it with the population. As to the property loss, our knowledge is relatively indefinite, but it suffices for the present purpose.

Consider first the value of insurance against the danger of death by earthquake. Seven hundred and nine deaths are reported to have been caused by the San Francisco earthquake, and about 76 deaths by earlier earthquakes, making a total of 785.* The total annual population for the same period, that is to say, the sum of the populations for the several years, was about 51,500,000.† Using these data, the annual premium on a policy for $1,000, payable only in the event of death by earthquake, is computed at one cent and a half, plus the cost of doing the business and the profit of the company. The minuteness of the earthquake risk may be further indicated by saying that it is one-tenth of the risk of death by measles. If a timid citizen of California should emigrate in order to escape the peril from earthquake, he would incur, during his journey, a peril at least two hundred times as great, whether he traveled by steamship, sailing vessel, railway car, motor car, stage, private carriage, or saddle; and if in emigrating he removed from San Francisco to Washington city he would incur, by change in environment as regards typhoid fever, an increment of peril eighteen times as great as the earthquake peril he escaped.‡

The danger to property is much more serious. Using the same method of computation as before, and availing myself of the expert knowledge of local statisticians, I have made a parallel estimate of the earthquake risk to buildings in California, and find it to be about five hundred times as great as the risk to life. If a company were to undertake the insurance of buildings against injury by earthquake, and base its premium on the experience of the State from 1800 to 1908, the average premium on a policy of $1,000 would be about $7, plus the cost of doing the business.§ This is nearly twice as large as a similar figure expressing the fire risk for the United States, as based on the accumulated experience of underwriters. Just as in the case of fire insurance, the premium on earthquake insurance would be adjusted to the local conditions; it would be higher for houses on soft ground than for those on bed rock, relatively high for houses near known earthquake foci, and very low for houses classed as earthquake-proof.

In making this estimate the fire damage occasioned by the earthquake damage of 1906 was treated as part of the earthquake damage. Had the direct earthquake damage alone been considered, the computation would have yielded a figure materially smaller, though still comparable with the basal fire insurance factor. But there seems no good reason for excluding the fire damage, for not only was the San Francisco conflagration caused wholly by the earthquake, but fire is a frequent sequel of the wrecking of buildings by seismic shocks. Nearly all our appliances for heating, cooking, and lighting are sources of fire danger when deranged by violence to the containing buildings, and if the agent of violence affects a large area, as in the case of earthquake, the appliances for extinguishing fires are very apt to be disabled at the same time.

It is possible that the estimate of the building risk is exaggerated by reason of its having been made just after the great disaster of 1906. It certainly would have been materially smaller if made by the same method just before that disaster. But this qualifying circumstance is largely if not wholly offset by the fact that various shocks of the same physical rank as that of 1906 wrought comparatively little havoc because at the time of their occurrence the areas shaken were sparsely populated—at least by house-building races. The Inyo earthquake of 1872, having its origin in Owens Valley, demolished the village of Lone Pine with a completeness not paralleled in 1906, and the falling walls crushed to death a tenth part of the village population. The shocks of 1812, affecting a tract on which Los Angeles, Santa Barbara and other large towns are now built, were limited in their destructive effect to the Spanish Missions because those were then the only houses; but the mission buildings fared badly, and it is related that thirty or forty mission Indians lost their lives. The earthquake hazard indicated by these occurrences was certainly not less than that emphasized by the recent disaster in a populous district, and yet the absolute losses they occasioned were so small as to have little influence on the totals used in the computation.

On the whole, weighing these and other factors of the problem as well as I am able, I am disposed to adhere to the estimate, not, indeed, claiming for it a high measure of precision, but regarding it as a fair approximation to the truth, and possibly as good as may be derived from the available facts.

It is needless to carry further the discussion of insurance rates. Its purpose has been served in showing that the earthquake risk to buildings in California is comparable with the fire risk and equally worthy of serious consideration. There is no present question of earthquake insurance, of which the function would be merely to distribute earthquake losses, but there is a question of the prevention of earthquake damage.

Earthquake damage is at least as preventable as fire damage. It is possible so to construct houses that they will neither collapse nor otherwise be vitally injured by such shocks as have visited California in the past. In a house so built there will be small danger from earthquake-started fires because they will be both accessible and quickly detected. It is wreckage that prevents the prompt extinguishment of the initial blaze. In a house so built there will be little damage to furniture, merchandise, and other valuable contents. With houses so built the life risk will become a vanishing quantity, for practically all earthquake casualties are directly due to the failure of buildings. And in a community thus protected in life and property the terror of the mysterious unheralded temblor—a factor far outweighing the actual personal peril—will gradually wear away.

In saying that earthquake damage is preventable I would not be understood to imply that the subject of earthquake-proof construction is at all adequately developed. Competent modes of construction are known, but the best modes, the most economic modes, the modes best adapted to American materials and conditions remain to be determined, and there is much need of investigation.

It should be the policy of the people and State of California to see that the necessary investigations are made, and that the results are embodied in the building regulations of all cities as well as in the entire building practice of the State. And, in order that the methods of construction may be properly adjusted to the very unequal local requirements, provision should be made for a seismic survey and the mapping of tracts of special earthquake danger.

* The casualties in 1906 are given as reported by the State Board of Health; those in earlier years were compiled from Holden's "Catalogue of Earthquakes on the Pacific Coast, 1769 to 1897."

† To obtain this figure the populations of the State on census years were platted on section paper and a curve of population drawn through them, thus graphically interpolating estimates for intervening years. For years earlier than 1850 estimates were based on data contained in Hittell's "History of California." The census returns do not include Indians. In making estimates of the population previous to 1850 the Mission Indians were included. The estimate includes the year 1908.

‡ The U. S. Census returns for the years 1901-5 give the following death rates, per 100,000, from typhoid: San Francisco, 27.0; Washington, 56.6. The statement in the text of course applies only to the risk of death from typhoid; the death rate from all causes was higher, in the same years, in the western city than the eastern.

§ In assembling data for this estimate I was greatly assisted by Prof. C. C. Plehn and A. W. Whitney, of the University of California, but these gentlemen are not to be held responsible for the estimate itself. The estimate involves, among others, the following assumptions: (1) in that part of San Francisco burned over in April, 1906, the loss from destruction and injury of buildings amounted to one-third the entire loss. (2) the ratio of sound value to assessed value of buildings in San Francisco in 1905 was 1.7; (3) the similar ratio for the entire State was 2.0; (4) the average value of buildings per capita in California was the same for the entire period 1800-1908 as for the single year 1905. Some of the elements of the estimate are as follows:

Damage to buildings in burned district of San Francisco in 1906 (= 1/3 × $350,000,000)	$117,000,000
Damage to buildings in San Francisco, outside burned district, 1906	7,000,000
Damage to buildings outside of San Francisco, 1906	15,000,000
Damage to buildings in California, 1800-1905.	20,000,000
Total earthquake damage to buildings in California, 1800-1908	$159,000,000
Total corresponding "exposure" (= sum of annual value of buildings in California 1800-1908)	$22,000,000,000
Basal insurance factor (= ratio of total loss to total exposure)	0.00723
Risk on policy of $1,000	$7.23

REGENERATION OF INDIA RUBBER.

A FIRM in Basle has patented a process of regenerating India rubber by heating and stirring finely divided rubber waste to 212 deg. F. or higher with ethers of the fatty, heterocyclic or aromatic series having boiling points higher than 212 deg. F., and precipitating the rubber from the solution thus obtained.

For example, 1 part of rubber chips is stirred, kneaded and heated to 250 or 275 deg. F. for 3 hours with 2 parts of commercial isoamylether. The thick, viscous solution is thinned with ethylether and filtered, and the ether is distilled off, the distillation being completed *in vacuo*. The residue is washed with warm alcohol and dried, yielding a tough coherent mass. For the isoamylether may be substituted cresolether, borneolether, pyrogallolether, eugenolbenzolether, etc.

A NEW INDUSTRY ON THE VICTORIA NYANZA

IN East Africa certain restless speculative spirits, no longer content with the beaten trade paths (produce of the forest, land, and plantations), are now seeking fresh fields and pastures new in the shape of new raw materials or semi-raw materials. A German African merchant, Mr. Paul Küller, has now succeeded in getting several Swiss, Alsatian, and French firms to listen to his proposals, as an expert in the silk industry, for the introduction of silkworm breeding on a large scale in German and British districts lying along the Victoria Nyanza. Africa owns various species of silkworms which are very closely related to the *Bombyx mori;* these are either single spinners or family spinners, that is to say, they either spin a single cocoon or else large family nests. Here family spinners are mostly met with; they are not so closely related to the Bombyx as the others, though they are very similar to it in appearance, being merely a little smaller, while the moth has fewer brown markings underneath the wings.

In Africa there are three species of family spinners, all of which originate from the same moth. On German territory only one species has so far been found, principally on the tree (*Ficus* family) the bark of which is used by the natives living round the lake for making cloth, hangings, etc.; so far these tribes have been destroying all the nests they could find, because the worms damaged the trees. It has now been discovered, however, that the caterpillars prefer other trees on which to spin their cocoons which are covered on the outside with a tough parchment-like integument. At present no one can say for certain on what trees or plants the worms will thrive best. The natives, however, assert that the worm is very fond of a plant which they largely use for fencing purposes, and it is said that this plant will do excellently for breeding purposes.

A considerable stretch of land has just been purchased at Bukoba, and will be planted with the African wild mulberry and other plants suitable for feeding purposes. In the wild state only from one to two nests (each containing about 250 worms) are found on each tree, but it will be possible to greatly augment this number under organized breeding systems. The natives have now been ordered to collect these nests and, up to the end of September last, from 70,000 to 80,000 have been secured. The German Residency at Bukoba is doing its utmost to promote the new venture with which, it is hoped, a new branch of activity may be introduced among the natives; these latter have already been taught to differentiate between the living and the dead nests, and several chieftains (including the powerful Sultan Kahigi) have even gone so far as to start breeding places on their own account.

The progress made on German ground is, thanks to the support lent by the authorities, much greater than that on British territory, although things are also making headway there. At Entebbe, the administrative capital of the Uganda colony, dead nests are now being prepared for exportation, the outer integument being split up and stripped off the cocoons, which are then pressed into bales by hand. During 1908 not many nests were thus treated, most of the nests brought in having been living and thus employed for breeding purposes. These nests are obtained even from remote regions, some of them having hailed from the western parts of Uganda, from Unyorro on Albert Nyanza, and from the Nile province. As Entebbe is not suitable for breeding in many ways, considerable areas of land have now been secured at Kampala and it is proposed to shift the industry there.

The material obtained is peculiarly adapted for the manufacture of plushes, embroidery silks, cheap velvets and the like. Support is almost certain from well-known Bradford firms and offers have been favorably considered by important South German silk spinners, so that a prosperous future may be predicted for the industry in due course. As the demand for raw silk is steadily increasing it is to be hoped that this prophecy will come true, and enable silk users throughout the world to become somewhat more independent of the Chinese and Italian markets, while the civilizing and economic value of such a movement for Africa itself is of the widest importance.

ENGINEERING NOTES.

According to experiments recently carried out by Prof. Albert Frank, and reported by him in the Zeitschrift des Vereines deutscher Ingenieure, the resistance of a surface perpendicular to the direction through which it is moved is 236 times that of the same surface moving through the air when it is parallel with the direction of motion. Thus the resistance offered to the motion of a thin plate normal to the direction of motion is 118 times that of a plate of the same area cutting through the air in a direction parallel to the motion, resistance in this case being offered by both sides of the plate.

It was thought, states the Review of the River Plate, that before the end of the present session of Congress the question of tubes in the city of Buenos Ayres would have been settled, and that at least the concessions applied for by the Western and Amalgamated Railways would have been sanctioned. Such, however, was not to be the case, as it has been resolved by a large majority to shelve the question until next year. This is a bad outlook for the city, which is not in a position to carry out the work, while the railway companies are, and the conditions that they offered to the government were satisfactory to the community.

Between 30,000 and 35,000 deaths and two million injured is the accident record in the United States during the last year among workingmen, according to a bulletin of accidents issued December 14th by the Bureau of Labor. Of those employed in factories and workshops, it is stated that probably the most exposed class are the workers in iron and steel. Fatal accidents among electricians and electric linemen and coal miners are declared to be excessive, while railway trainmen were killed in the proportion of 7.46 deaths per 1,000 workmen. The bulletin declares that it should not be impossible to avert at least one-third and perhaps one-half of the accidents by intelligent and rational methods of factory inspection, legislation and control.

During the latter part of the month the construction of an important new Alpine railway line was commenced. This line, which is to be driven electrically throughout its entire length, is to establish a direct connection between Graubünden, in the Alps, and eastern Lombardy. It is to run via Edolo to Brescia. The section between Brescia and Edolo is already being built, and will be finished next year; a Swiss firm has asked the Italian government to grant a concession for the construction of the section from Edolo to Tirano. As the short Bernina railway in Switzerland is also already in the course of construction, there will exist, in two or three years' time, a short railway route between Graubünden and Brescia. Consequently a much shorter route will also be established between Zurich and Venice, for it will not be necessary to touch Milan.

An extended series of experiments was carried out during 1905 and 1906 by Herr C. Eberle, at the instance of the Society of German Engineers, and the results were published in the Zeitschrift of that body early in 1908. Herr Eberle conducted his experiments on pipes of 2.8 inches and 6 inches internal diameter, with steam velocities ranging from 23 feet to 343 feet per second; the steam pressures varied from 43 pounds to 142 pounds per square inch absolute, and superheats up to 80 deg. F. were employed. From the data thus obtained, he derived the following formula for the pressure drop, p, in pounds per square inch:

$$p = 222.2\, G\, L\, v^2/D^2 \times 10^8,$$

where G = specific weight of steam in pounds per cubic feet; L = length of pipe in feet; v = velocity of steam flow in feet per second; D = diameter of pipe in feet. The coefficient 222.2 used is only 70 per cent of that proposed earlier by Prof. Gutermuth for the same formula. Herr Eberle also found that the resistance offered by each valve in the pipe line was equivalent to that of 53.8 feet of additional pipe.

According to the results of recent investigations made by continental metallurgists, it would appear that, contrary to most published references, in the blowing of a basic converter 25 per cent of the phosphorus is removed before all the carbon is burned out. The loss in iron consequent on the removal of 6.7 to 7.8 per cent of impurities amounted to 8.2 and 10.7 per cent, of which 2.7 and 4.7 per cent were burnt during the after-blow in order to remove the last tenth per cent of phosphorus. The combustion of this element produces a high temperature, and the affinity of iron for oxygen becomes greater at a high temperature than that of phosphorus. The loss of iron can be diminished by cooling the bath during the after-blow by scrap additions or lime ore briquettes. It is more economical to remove phosphorus in the open-hearth furnace when this element is present in considerable quantities, as it can be concentrated in an iron-free slag rich in phosphorus and suitable for use as a fertilizer.

SCIENCE NOTES.

The Deutsche Orient Gesellschaft (Berlin) states that a German expedition, engaged in making excavations on the supposed site of ancient Jericho, a collection of mounds in the vicinity of the village of Ericla, near the Dead Sea, encountered the exterior wall of a vanished city at a depth of 8 feet below the surface. The excavators were astonished at the technical excellence of the construction. The wall consisted of three parts. The natural rock foundation is overlaid with a filling of loam and fine gravel, upon which a well-laid rubble wall, heavily bulging externally, is superimposed to the height of 20 feet, the breadth being from 6½ feet to 8 feet. Enormous blocks are partially employed for the lower part of the wall. Finally upon this imposing foundation is the fortification wall proper, built of clay bricks. In one place this reaches a height of 8 feet, but it would seem to have been considerably higher, and must have dominated the whole plain without the city. The walls are estimated to have extended nine hundred yards. Four hundred and fifty yards have already been laid bare by the expedition.

According to the theory of Stahl, the green color of foliage is a complementary adaptation to the color of sunlight, in which, when filtered through the atmosphere, red and yellow rays preponderate. Similar complementary adaptation is exhibited, according to Schorler, by the flagellates and diatoms of the black ponds of the Erz Mountains, between Saxony and Bohemia. In clear water these flagellates are golden yellow and the diatoms are brown, but both assume a green hue in the coffee-colored water of these ponds. In the diatoms the change is dependent on the size. The largest forms retain their normal brown color and somewhat smaller species show an admixture of green pigment cells with the brown, the combination producing an olive-green effect. Still smaller diatoms show the pure green of chlorophyl, and the smallest are pale bluish green. The flagellates are green with a slight tinge of blue. This change of color in the same direction in two organisms so unlike can only be attributed to the action of external influences, of which the brown moor water is unquestionably the chief. Engelmann and Gaidukov have discovered that blue and red algae possess the faculty of complementary chromatic adaptation, or, in other words, the power of adapting themselves to changed conditions of illumination by producing pigment cells of a color complementary to that of the illumination, with the result that the incident light is more fully absorbed and utilized. Thus these algae become green in red light, blue-green in orange light, red in green light and yellow-brown in blue light. The moor water, which appears coffee colored in thick, and yellow in thin layers, absorbs the more refrangible rays and transmits the red and yellow rays which develop complementary shades of green in the organisms, thus increasing their power of absorption and assimilation and making life possible under adverse conditions.

For the explanation of halves and similar phenomena, it is commonly assumed that ice crystals, in falling through the atmosphere, assume positions which reduce the resistance of the air to a minimum, needle-shaped crystals having their axes, and flat crystals their faces, vertical. This view has recently been disputed. Besson, in particular, has rejected it in consequence of experiments on the descent of models of ice crystals through liquids of small density. Besson's conclusions are confirmed by the direct operations of Schmidt, who, in three balloon ascensions, saw the sun's image reflected by flat ice crystals in a manner which proved that the faces of the crystals were horizontal. In April, 1907, an ascension was made in a rainstorm, but at higher levels the rain was replaced by snow. At an elevation of 1,000 feet the snowflakes were shapeless, at 1,700 feet star-shaped crystals were observed, floating in the snow cloud, from which the balloon emerged at a height of 2,600 feet. The sun, shining brightly from a deep blue sky, was surrounded by a large halo and accompanied by a "mock sun." During the descent through the cloud, which had meanwhile been partly dissipated, the mock sun remained visible and the basket was surrounded by sparkling ice crystals, which, when caught on a black cloth, proved to be flat, star-shaped and from 1/12 to 1/8 inch in diameter. The mock sun was the image of the sun reflected by these crystals. It was composed of a bright disk about 2 deg. in diameter (four times the apparent diameter of the sun) surrounded by a hazy ring nearly 7 deg. in diameter. This enlargement was caused by the crystals, in falling, oscillating about 3 deg. about their mean horizontal position. A still more convincing observation was made in April, 1908, when the reflected image of the sun appeared in a cumulus cloud in which very small flat ice crystals had been encountered. When the sun was seen by reflection in a pond or stream the reflected image appeared exactly at the place where the image reflected by the ice crystals had been seen.

TRADE NOTES AND FORMULÆ.

Cement for Meerschaum.—Stir very fine meerschaum chips with white of egg or dissolve caseine in water glass, stir in finely powdered magnesia and use the cement at once. It hardens very quickly.

Japanese Cleansing Cream. (Spot-removing preparation.)—125 parts of white olive oil soap, 125 parts of 26 deg. caustic ammonia, 60 parts 95 deg. alcohol, 30 parts of glycerine, 60 parts of sulphuric ether, and enough water to bring the whole up to 4,000 parts. The finely cut soap is dissolved in 1,000 parts of hot water and the remaining ingredients and sufficient water to make up the 4,000 parts added.

Washable Lime Paint (according to Resenschek of Munich).—The powder, composed of 3 parts silica, 3 parts crushed marble, 2 parts sandstone, 2 parts calcined china clay and 2 parts of slaked lime furnishes a paint body that may be employed in conjunction with any of the pigments suitable for use with lime, and turns as hard as stone upon being sprinkled with water, without losing in porosity.

Japanese Bell Metal (Karakane) of Various Qualities.—The best sort consists of 10 parts of copper, 4 parts of tin, ½ part of iron, 1½ part of zinc. Second grade: 10 parts of copper, 2⅓ parts of tin, 1½ part of lead, ½ part of zinc. Third grade: 10 parts of copper, 3 parts of tin, 2 parts of lead, ½ part of iron, 1 part of zinc. Fourth grade: 10 parts of copper, 2 parts of tin, 2 parts of lead.

Russia Leather Varnish.—For restoring damaged Russia leather articles the following preparation is adopted: 100 parts sandarac and 50 parts of mastic are dissolved in 800 parts 95 per cent alcohol in a bottle, by frequent shaking, or in the water bath and the solution strained. 10 parts of Venice turpentine and 5 parts each of elemi and castor oil are melted together, the molten solution added to the above resinous mixture, together with 10 parts of birch-tar oil and the coloring substance, and filtered. As coloring substance, for red Russia leather varnish, 5 parts of fuchsine, for black varnish 40 parts of nigrosine may be used.

Impregnation of Wood as a Protection Against Worms.—I. 860 parts of linseed oil and 40 parts of creosote, mixed. II. 1,000 parts linseed oil, 50 parts creosote, 30 parts oil of turpentine and 44 parts of borate of manganese are mixed by first dissolving the manganese by boiling in linseed oil and when cold adding the creosote and oil of turpentine.

Impregnation of Mantle Fabrics.—To make military cloth waterproof, in the Austro-Hungarian military equipment depots, a 1.7 per cent solution of acetate of alumina is used. Acetic acid is separated and basic acetate of alumina, insoluble in water, is deposited in the fibers. This deposit reduces the penetrability of the water, but does not in any manner injure the fabric.

Hydrofugin.—This is a composition to make substances of flax, cotton, silk or wool waterproof, although they remain permeable to the air. According to Menotti, it is prepared as follows: 10,000 parts of sulphate of alumina, or the same quantity of alum, sulphate of copper or protochloride of tin are rubbed down in a sufficiently large vessel into powder. In another vessel place 400 parts of oleic, stearic or margaric acid, or as much soap or saponifiable substance; add 9,000 parts of alcohol, in which, under the influence of heat, the mass is dissolved. This solution is then poured into the first vessel, containing the salt used, mixed with it and the whole kept at 104 deg. F. until the mass, which constitutes the hydrofugin, becomes solid. To render flax or cotton fabrics waterproof with this substance, 1 part of it is mixed with 100 parts of water, the fabric is passed through this fluid and it is then suspended, stretched, to dry, which completes the process. For the treatment of silk and woolen fabrics, 1 part of hydrofugin is mixed with 200 parts of water.

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